

10066 20/12/24

SET-1

Name of Course : B.Sc. Hons. (Physics)_NEP:UGCF-2022
Semester : V
Name of the Paper : Electromagnetic Theory
Unique Paper Code : 2222013501
Duration: 3 Hours

Maximum Marks: 90

(Write your Roll No. on the top immediately on receipt of this question paper.)

Question No. 1 is compulsory.

Answer any four of the remaining five.

Use of non-programmable calculator is allowed.

1. Attempt any 6 parts of the following:

6×3=18

(i) Show that the time average Poynting vector for time varying fields is given by:

$$\langle \vec{S} \rangle = \frac{1}{2} \text{Re} (\vec{E} \times \vec{H}^*)$$

(ii) The electric field intensity for an electromagnetic wave is expressed as

$$\vec{E} = 120 \sin(10^{11} t) \hat{i} \text{ V/m}$$

Calculate the magnitude of displacement current density and the conduction current density. Given: $\sigma = 8.0 \text{ S/m}$ and $\epsilon_r = 1$.

(iii) A light beam is incident from denser medium ($n_1=2.0$) on a rarer medium ($n_2=1$). Plot the reflection coefficients for the parallel and perpendicular components as a function of the angle of incidence.

(iv) What will be the minimum thickness of a calcite plate that would convert a plane polarized light of wavelength $8000 \text{ \AA}$ into circularly polarized light? (Given: $n_o=1.5533$ and $n_e=1.5443$).

(v) Show that if the electric field of the incident wave lies in the plane of incidence, the electric fields of the reflected and transmitted waves will also lie in the plane of incidence.

(vi) The refractive indices of quartz for right-handed and left-handed circularly polarized light of wavelength $7000 \text{ \AA}$ are 1.65207 and 1.65201 respectively. Calculate the rotation of plane of polarization of light produced by a plate of thickness 0.9 mm .

(vii) Show that a beam of plane polarized light may be regarded as composed of two equal and opposite circularly polarized light.

2. (a) State and establish Poynting's theorem for electromagnetic fields. Compare it with the equation of continuity and give an interpretation of the Poynting vector. (10)

(b) What are electromagnetic potentials? Discuss their non-uniqueness and hence explain the significance of gauge transformation. (8)

3. (a) Starting from Maxwell's equations in an isotropic, homogeneous dielectric material, show that electromagnetic waves are transverse in nature. Calculate the time average of

momentum density stored in these fields.

(12)

(b) Calculate the intrinsic impedance and wave velocity for a conducting medium with $\sigma = 60$ MS/m and $\mu_r = 1$, at frequency of 120 MHz.

(6)

4.(a) Derive Fresnel's relation for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when an electric vector of the incident wave is perpendicular to the plane of incidence.

(10)

(b) A uniform plane wave is incident on planar boundary separating regions 1 and 2, with $\sigma_1 = \sigma_2 = 0$ and $\mu_{r1} = \mu_{r2} = 1$. Find the ratio of $\epsilon_{r2}/\epsilon_{r1}$, if 20 % of the incident wave energy is (a) reflected and (b) transmitted. (Assume normal incidence).

(8)

5.(a) Distinguish between positive and negative crystals in terms of double refraction. How are these crystals used to make quarter wave plates? Explain how the quarter wave plate is used in producing elliptically and circularly polarized light.

(12)

(b) Show that in an electrically anisotropic dielectric medium, the permittivity tensor is symmetric in nature.

(6)

6. (a) Derive wave equation for $\vec{E}$ of electromagnetic wave in a symmetric planar dielectric wave guide with refractive index profile as:

$$\begin{aligned} n &= n_1, & -d/2 < x < d/2 \\ n &= n_2, & -d/2 > x > d/2 \end{aligned}$$

($n_2 < n_1$) where d is the width of the guide.

Using the boundary conditions, obtain the eigenvalue equation for symmetric TE modes. (12)

(b) Find the state of polarization of electromagnetic wave having electric field vector:

$$\vec{E} = 2 \cos(\omega t - kz) \hat{i} - 2 \cos\left(\omega t - kz - \frac{\pi}{2}\right) \hat{j} \quad (6)$$

Physical Constants :

$$\begin{aligned} \epsilon_0 &= 8.85 \times 10^{-12} \text{ Farad/m}, & \mu_0 &= 4\pi \times 10^{-7} \text{ Henry/m} \\ c &= 3 \times 10^8 \text{ m/s}, & m_e &= 9.11 \times 10^{-31} \text{ kg} \end{aligned}$$

19/12/24
[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1104

I

Unique Paper Code : 2222013502

Name of the Paper : Quantum Mechanics – I

Name of the Course : B.Sc. Hons. – (Physics)_
NEP: UGCF-2022

Semester : V

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt only **five (5)** questions.
3. Question No. 1 is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

P.T.O.

1. Attempt any six :

(6×3=18)

- (i) Write the conditions required for physical acceptability of wave function.
- (ii) What are stationary states? Why are they called so?
- (iii) Let $\psi_0(x)$ and $\psi_2(x)$ are the ground state and second excited state energy eigenfunctions of a particle moving in a harmonic oscillator potential with frequency ω . At $t = 0$, the wavefunction of the particle is
$$\psi(x, 0) = \frac{1}{\sqrt{3}} \psi_0(x) + \psi_2(x).$$
 Find $\psi(x, t)$ for $t \neq 0$.
- (iv) List the four quantum numbers needed to describe an atomic electron? What is their physical significance?
- (v) For 6g state of hydrogen atom, what are the values of quantum number n , l , m_l and energy of the state?
- (vi) Compute the commutator $[x, p^2]$.
- (vii) Show that (a) $[\hat{L}_x, \hat{x}] = 0$ (b) $[\hat{L}_x, \hat{y}] = i\hbar \hat{z}$

2. (i) Solve the Schrodinger equation for a particle having energy $E < V_0$ for a square well potential of finite depth V_0 . Discuss the graphical representation of the transcendental equations.

- (ii) Obtain the mathematical form of position operator in momentum space. (15,3)

3. The potential energy of a simple harmonic oscillator of mass m , oscillating with angular frequency ω is

$$V(x) = \frac{1}{2} m\omega^2 x^2.$$

- (i) Write the time independent Schrodinger equation. Using the time independent schrodinger equation, evaluate the energy for the eigenstate

$$\psi_0(\alpha x) = \sqrt{\frac{\alpha}{\pi^{1/2}}} e^{-\alpha^2 x^2}; \alpha = \sqrt{\frac{m\omega}{\hbar}}, \text{ where } \omega \text{ is the angular frequency of the oscillator.}$$

- (ii) Find $\langle p \rangle$ for ψ_0 .

- (iii) If the harmonic oscillator is in the ground state at $t=0$, what will be the wavefunction

$$\text{at } t = \frac{\pi}{2\omega}. \quad (18)$$

4. Write the Schrodinger equation for a 3D hydrogen atom in spherical polar coordinates. Derive three separate equations for r , θ , ϕ using the method of separation of variables. Solve the equation for θ to obtain the normalized eigenfunctions. (18)
5. (i) What is spin angular momentum? Discuss the experimental observations which could not be accounted for without introducing the spin angular momentum.
- (ii) What are Pauli Spin matrices. For $s = \frac{1}{2}$, obtain the matrix form of S_z .
- (iii) What is total angular momentum? After defining ladder operator J_+ and J_- obtain (a) $[\hat{J}_+, \hat{J}_-]$
 (b) $[\hat{J}_+, \hat{J}_z]$. (6+6+6)
6. (i) Find $\langle r \rangle$ and $\langle r^2 \rangle$ for an electron in the ground state of the hydrogen atom? Express the answer in terms of Bohr radius.
- (ii) At a given instant of time, a system is in the state $Y(\theta, \phi) = \sqrt{\frac{3}{4\pi}} \sin\theta \sin\phi$. Determine the expectation values of L_z and L^2 . (9,9)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1123

I

Unique Paper Code : 2222013503

Name of the Paper : Digital Electronics

Name of the Course : B.Sc. Hons.-(Physics)_NEP:
UGCF-2022

Semester : V

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. 1 is compulsory.
4. **All** questions carry equal marks.

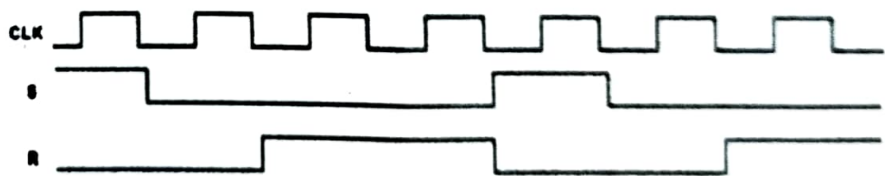
1. Attempt any **Six** parts (all parts carry equal marks)
(3×6=18)
 - (a) Write three differences between synchronous and asynchronous counters.

P.T.O.

- (b) What are Passive and Active components in electronics? Explain giving appropriate examples.
 - (c) Why JK Master-Slave flip flop is preferred over level triggered JK latch?
 - (d) Explain the role of control voltage (pin 5) and reset (pin 4) in IC 555 timer.
 - (e) Subtract $(32)_{10}$ from $(12)_{10}$ using 2's complement method in 8-bit representation.
 - (f) Draw the circuit of a 5-bit even parity generator. Use the binary number 1100 and 0111 to generate the output.
 - (g) Realize a 2-input OR gate using diodes and resistors and briefly explain its working.
2. (a) A four variable truth table has high output when at least two input variables are in the high state. Draw the truth table and derive the minimized expression using Boolean algebra. Realize the logic circuit using 2-input NAND gates only.
- (b) Determine the minimized Boolean expression for the function: $F(A,B,C,D) = \sum m(0,8,9,10) + d(1,2,7)$ using K-map method and design the logic circuit using basic gates.
3. (a) Implement and explain the working of a 4-bit binary addition and subtraction circuit that utilizes 2's

complement method for subtracting two numbers. Suppose the above circuit is used to subtract two binary numbers and generate carry 0 output and a sum output of 11001100. Explain how this circuit can be used to get the final answer.

- (b) Implement a 16:1 Multiplexer using two 8:1 Multiplexers and explain briefly it's working. (Use only the simple block diagram of 8:1 multiplexer to implement the above). (10,8)
4. (a) Explain the working of a positive level triggered SR flip flop with the help of a circuit diagram and truth table. Explain why for $S=1$ and $R=1$ the Q output is unpredictable and lead to race condition. Draw the output waveform for the following conditions:



- (b) Using the method of excitation table design the circuit of a JK flip flop using SR flip flop. Use block diagram of SR flip to draw the final circuit. (10,8)

5. (a) Design a synchronous self-correcting MOD-6 count down counter using the method of excitation table. Use negative edge triggered JK flip flop to design the counter. The initial state of the counter is 000.
- (b) Explain the difference between Serial-in-serial-out (SISO) and Serial-in-parallel-out (SIPO) shift registers? Explain the working of a 4-bit SISO shift register with suitable waveform, if the binary number 1100_2 has to be shifted from the LSB side? (10,8)
6. (a) Draw circuit diagram of a monostable multivibrator using IC 555 timer and explain it's working. Derive the expression for pulse width during which it is in unstable state.
- (b) IC 555 Timer is used to design a monostable configuration with $R = 3.3 \text{ M}\Omega$ and $C = 0.22 \text{ }\mu\text{F}$. Determine the pulse width (time for which output is high) of the output wave. Draw the waveforms across capacitor and at the output if the time period of the applied trigger input is half the above calculated pulse width. (10,8)

1249

01/01/2025 R

Roll No.

Name of the Department : Department of Physics and Astrophysics
Name of the Course : B.Sc. Hons. (Physics) NEP: UGCF-2022
Name of the Paper : Communication Systems (DSE paper)
Semester : V- Semester
Unique Paper Code : 2223010015
Question paper Set number : Set I
Duration : 2 hours
Maximum Marks : 60 Marks

Instructions for Candidates:

- (a) Write your Roll No. on the top immediately on receipt of this question paper.
- (b) Attempt **FOUR** questions in all. Question number **one** is compulsory.
- (c) Non-programmable scientific calculator is allowed.

Q1 Attempt any five parts from this question. All questions carry same marks (3x5=15)

- (a) State the difference between analog and digital modulation. Give one example of each.
- (b) Determine the percent power saving when the carrier wave and one of the sidebands is suppressed in an AM wave modulated to a depth of 50%.
- (c) Explain the need for modulation in communication?
- (d) Draw PPM and PWM wave forms for a sinusoidal modulating signal.
- (e) Why is the uplink frequency kept higher than the downlink frequency in satellite communication?
- (f) What information is contained in the SIM number?

Q2

- (a) Define Amplitude Modulation (AM) and write mathematical expressions for AM. The output signal from an AM modulator is.

$$V_{AM}(t) = 5 \cos(1800\pi t) + 20 \sin(2000\pi t) - 5 \cos(2200\pi t)$$

Determine the following.

- (i) Frequency and amplitude of modulating signal
- (ii) Frequency and amplitude of carrier signal
- (iii) Modulation index

- (iv) Ratio of the power in the sidebands to the power in the carrier. (7)
- (b) Define the two types of angle modulation. (2)
- (c) A single tone modulating signal $\cos(15\pi \cdot 10^3 t)$ frequency modulates a carrier of 10 MHz and produces a frequency deviation of 75 KHz. Find the modulation index and phase deviation produced in FM wave. If another modulating signal produces a modulation index of 100 while maintaining the same deviation, find the frequency and amplitude of the modulating signal. Assume $k_f = 15 \text{ KHz/volt}$. (6)

Q3

- (a) State and prove sampling theorem. Calculate the Nyquist rate and sampling frequency for analog signal is expressed by the equation (7)

$$x(t) = 5 \cos(100\pi t) + 10 \sin(500\pi t) - 8 \cos(300\pi t)$$
- (b) What is Pulse Amplitude Modulation (PAM)? Draw the circuit of a Pulse Amplitude modulator and explain its working. List the disadvantages of PAM. (8)

Q4

- (a) Sketch ASK, FSK and BPSK waveforms for the sequence: 1011011010. (3)
- (b) Describe in detail the three basic operations involved in Pulse Code Modulation. (6)
- (c) Distinguish between Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM). (6)

Q5

- (a) Draw and explain the block diagram of transponder in a communication satellite. What are the advantages of a geostationary satellite? (8)
- (b) Why is mobile phone called a cellphone? Explain the concept of cell sectoring and cell splitting in mobile communication? (7)

SL NO of QP : 5834
 Unique Paper Code : 32221501
 Name of the Paper : Quantum Mechanics and Applications
 Name of the Course : B.Sc.(Hons)-Physics: CBCS
 Semester : V semester
 Duration : 3 hours
 Max. Marks : 75 marks

11/12/24

Medium of setting the Question paper: English Language
Attempt FIVE questions in all .Question No.1 is compulsory.

All questions carry equal marks

Non programmable calculators allowed

1. Attempt any **five** of the following

a) If A and B are both Hermitian operators. Which of the following three operators are Hermitian?

i. $i(AB - BA)$

ii. $(AB - BA)$

iii. $\frac{(AB+BA)}{2}$

b) Calculate $[xp, x^2]$ and $[xp, p^2]$.

c) Consider the wave function of the form $\Psi(x) = \int_{-\infty}^{+\infty} dk \Phi(k) e^{ikx}$; where $\Phi(k)$ is a function localised sharply at $k = k_0$. Find the value of $\Psi(x)$, if $\Phi(k) = \exp[-L^2(k - k_0)^2]$. L having the unit of length.

d) Find the probability current density $J(x)$ for the wave function $\psi(x) = N(x)e^{iS(x)/\hbar}$. Where $N(x)$ and $S(x)$ are real constants.

e) Write the spectroscopic term corresponding to the quantum numbers $n = 3, l = 2, s = \frac{1}{2}$.

f) Prove the commutator relation $[L_z, \sin^2\phi] = 2i\hbar(\sin^2\phi - \cos^2\phi)$, where ϕ is azimuthal angle.
 (5×3=15)

2.

a) Prove the relation for any dynamical observable operator Q ; $\frac{d}{dt} \langle Q \rangle = \frac{i}{\hbar} \langle [H, Q] \rangle + \langle \frac{\partial Q}{\partial t} \rangle$, where H is the Hamiltonian of the system which is hermitian. Using this relation find the value of $\frac{d}{dt} \langle XP \rangle$. Where X and P are position and momentum operators respectively.

b) The state of particle is represented by the wave function : $C_0 e^{-\alpha x^2}$, where $C_0 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4}$ and $\alpha = \frac{m\omega}{2\hbar}$. Find the uncertainty relation (i.e $\Delta x, \Delta p$).
 (9,6)

3.

a) A state of particle is represented by linear combination of two wave functions $\phi_1(x)$ and $\phi_2(x)$ as : $\psi(x, 0) = 3\phi_1(x) + 4\phi_2(x)$.

i. Normalize $\Psi(x, 0)$.

ii. Find the wave function at later time t ($\Psi(x, t)$).

iii. Find the probability density and show that it oscillate with frequency $\omega = \frac{E_2 - E_1}{\hbar}$

b) An electron is moving freely inside a one-dimensional infinite potential box with walls at $x = 0$ and $x = L$. If the electron is initially in the ground state ($n = 1$) of the box and if suddenly quadruple the

size of the box (the right hand wall is moved instantaneously from $x = L$ to $x = 4L$). Calculate the probability of finding the electron in :

- i) The ground state of the new box and
- ii) The first excited state of the new box.

4.

- a) Using Frobenius method solve the Schrodinger equation for a Linear Harmonic Oscillator to show that the energy eigenvalues are $E_n = (n + \frac{1}{2})\hbar\omega$.
- b) Consider a system whose wave function at $t = 0$ is $\psi(x, 0) = \frac{A}{\sqrt{30}}\phi_0(x) + \frac{4}{\sqrt{30}}\phi_1(x) + \frac{1}{\sqrt{6}}\phi_4(x)$; where $\phi_n(x)$ is the wave function of the n th excited state of an infinite square well potential of width a and whose energy is $E_n = \frac{\pi^2\hbar^2n^2}{2ma^2}$.
 - i) Find A so that $\psi(x, 0)$ is normalized.
 - ii) If measurement of energy is carried out, what are the values that will be found and what are the corresponding probabilities?
 - iii) Calculate the average energy.

(9,6)

5.

- a) An atomic state of H- atom is represented by the following wave function :

$$\psi(r, \theta, \phi) = \frac{1}{\sqrt{2a_0^3}} \left(1 - \frac{r}{2a_0}\right) e^{-r/2a_0} \cos\theta ; \text{ where } a_0 \text{ is constant.}$$

- i) What are the quantum numbers (n, l, m) associated with this state
- ii) Calculate the location at which the radial probability density is maximum.
- iii) Calculate the expectation value of radial coordinate in this state.

b)

- i) Calculate the expectation value of potential energy ($\langle V(r) \rangle$) in the ground state of the hydrogen atom
- ii) Show that in the ground state $E = \langle V(r) \rangle / 2$, where E is the total energy.
- iii) Use the relation $E = T + V(r)$, calculate the expectation value of kinetic energy ($\langle T \rangle$) in the ground state and show that $\langle T \rangle = -\langle V \rangle / 2$. (9,6)

6.

- a) Explain Normal Zeeman Effect with examples and energy diagram.
- b) Describe Stern Gerlach Experiment with necessary theory. What does it demonstrate?

(7,8)

7.

- a) What is spin orbit coupling? Calculate the change in energy of an electron due to this.
- b) Consider the state in which $l = 2$ and $s = 1/2$. For the state with the largest possible j and largest m_j , calculate the angle between $\mathbf{L}$ and $\mathbf{S}$.

(10,5)

Useful integral

$$\int_{-\infty}^{+\infty} dx \exp(-\alpha x^2 + \beta x) = \sqrt{\frac{\pi}{\alpha}} \exp(\beta^2/4\alpha)$$

$$\int_0^{+\infty} dx x^n \exp(-\alpha x) = \frac{n!}{\alpha^{n+1}}$$

19/12/24 R
[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5888

I

Unique Paper Code : 32221502

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. Hons. – (Physics)_**
CBCS-LOCF

Semester : V (Reappear Paper)

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Attempt **four** questions from the remaining questions.

P.T.O.

1. Attempt any **five** parts.

(a) Write three points of difference between crystalline and amorphous solids. (3)

(b) Prove that for a SC lattice, $d_{100} : d_{110} : d_{111} = \sqrt{6} : \sqrt{3} : \sqrt{2}$; where 'd' represents interplanar distance in a crystal. (3)

(c) Calculate the Debye vibrational frequency of diamond. Assume the Debye temperature of diamond is 2230 K.

Given Plank's constant (h) = 6.6×10^{-34} J-s and Boltzmann's constant (k_B) = 1.38×10^{-23} J/K. (3)

(d) Distinguish between conductors, semiconductors, and insulators on the basis of the band theory of solids, with suitable energy band diagrams. (3)

(e) State the difference between Diamagnetism, Paramagnetism and Ferromagnetism. (3)

(f) Define 1st order and 2nd order phase transitions with examples (3)

(g) Differentiate between Type I and Type II superconductors with the help of diagram. (3)

2. (a) Prove that the reciprocal lattice vector G_{hkl} is perpendicular to the crystal plane (h, k, l) and that the inter planar spacing is

$$d_{hkl} = \frac{2\pi}{|G_{hkl}|}$$

- (b) Prove that reciprocal lattice of a FCC lattice is a BCC lattice. Name a lattice which is self-reciprocal.
- (c) Determine Miller indices of a plane that makes intercepts of 2 Å, 3 Å and 4 Å on axes of an orthorhombic crystal with $a : b : c = 4 : 3 : 2$.
(7,5,3)
3. (a) Derive Laue's Equations to describe the scattering of x-rays by crystal.
- (b) A superconductor metal has a critical temperature of 3.7 K at zero magnetic field and a critical field of 0.0306 Tesla at 0K. Find the value of critical field at 2K.
(10,5)
4. (a) Derive an expression for the specific heat of a solid based on the Debye model and demonstrate that it varies as T^3 at low temperatures.

- (b) Calculate the number of optical and acoustical phonon branches in a NaCl crystal containing two atoms per primitive unit cell. (10,5)
5. (a) Write down the basic assumptions of Drude's model for describing electron motion in metals. Obtain the expression for the Hall coefficient in a metal and explain the information it provides.
- (b) The energy dispersion relation for an electron in a one-dimensional crystal with a lattice constant 'a' is given by $E(k) = \alpha - \beta \cos ka$, where α and β are constants, and k is the wave vector. Find the effective mass (m^*) of the electron at the center of the first Brillouin zone ($k=0$). (10,5)
6. (a) Derive the expression for the magnetic susceptibility of a Diamagnetic material using Classical Langevin's theory.
- (b) Show that the area of the B-H curve gives the Hysteresis energy loss. (9, 6)
7. (a) Explain the various sources of polarizability?
- (b) Find the expression for the total polarizability of solids. (6,9)

23/12/24
[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5977

I

Unique Paper Code : 32227502

Name of the Paper : Advanced Mathematical
Physics – I

Name of the Course : B.Sc. (Hons.) Physics
(CBCS-LOCF)

Semester : V

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. **All** questions carry equal marks.
4. Non-programmable Scientific calculator is allowed.

1. (a) Determine whether the set of real numbers equipped with the binary operation $*$ defined by

$$a * b = a^b$$

forms a group or not.

(5)

P.T.O.

5977

- (b) Let T be the linear transformation on $\mathcal{R}^2$ defined by

$$T(x, y) = (2x + 3y, 2x - 5y)$$

and S_1 and S_2 be two bases of $\mathcal{R}^2$ given by

$$S_1 = \{(1,0), (1,1)\}, S_2 = \{(1,2), (2,1)\}$$

Find the matrix representation of T w.r.t. bases S_1 and S_2 . (10)

2. (a) If H is a Hermitian matrix and I is the unit matrix of the same order as H , determine whether $A = (I - iH)(I + iH)^{-1}$ is a Unitary matrix or not. (5)

- (b) Given that eigenvalue of square matrix A is λ , prove that eigenvalue of matrix $\text{adj}(A)$ is $\frac{|A|}{\lambda}$. (5)

- (c) Find the values of x and y such that given matrix B is orthogonal :

$$B = \frac{1}{6} \begin{bmatrix} 1 & \sqrt{10} & x \\ -5 & \sqrt{10} & y \\ \sqrt{10} & 4 & \sqrt{10} \end{bmatrix} \quad (5)$$

3. (a) Find the eigenvalues and eigenvectors of the matrix C ,

$$C = \frac{1}{6} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 2 & 0 \\ -3 & 5 & 2 \end{bmatrix}$$

Can C be diagonalised or not? Give reason(s).
(10)

- (b) State Cayley-Hamilton theorem. Verify it for the matrix F and hence find F^{-1} , where

$$F = \begin{bmatrix} 2 & -1 \\ 3 & -1 \end{bmatrix}. \quad (5)$$

4. (a) Find e^R for the matrix R , where

$$R = \frac{1}{2} \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix} \quad (7)$$

- (b) Solve the coupled differential equations

$$\dot{y} = -y + 4z$$

$$\dot{z} = 3y - 2z$$

$$\text{where, } y(0) = 3, z(0) = 4 \quad (8)$$

5. (a) Show that

$$\epsilon_{ijk} \epsilon_{kpq} = \delta_{ip} \delta_{jq} - \delta_{iq} \delta_{jp}$$

and hence prove that

$$\epsilon_{ijk} \epsilon_{ijk} = 6 \quad (8)$$

(b) If
$$S = \begin{bmatrix} x_2^2 & x_1 x_2 \\ -x_1 x_2 & x_1^2 \end{bmatrix},$$

determine whether or not S is a Cartesian tensor of rank 2 in 2-dimension. (7)

6. Using tensors, prove the following :

(a) $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \bullet \vec{C}) - \vec{C}(\vec{A} \bullet \vec{B})$ (7)

(b) $\vec{\nabla} \times (\vec{f} \times \vec{g}) = (\vec{g} \bullet \vec{\nabla})\vec{f} - (\vec{f} \bullet \vec{\nabla})\vec{g} + \vec{f}(\vec{\nabla} \bullet \vec{g}) - \vec{g}(\vec{\nabla} \bullet \vec{f})$ (8)

7. (a) Prove that divergence of a vector field transforms like a tensor of rank 2. (5)

(b) Obtain an expression for Moment of Inertia tensor. Also, prove that it is symmetric tensor of rank 2. (10)

(a) A covariant tensor has components $(xy, 2y - z^2, xz)$. Find its covariant components in spherical coordinates. (10)

(b) Find g_{ij} and g corresponding to $ds^2 = 5(dx^1)^2 + 3(dx^2)^2 + 4(dx^3)^2 - 6 dx^1 dx^2 + 4 dx^2 dx^3$. (5)

23/12/24
[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5979

I

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

Name of the Course : **B.Sc. (Hons.) Physics-CBCS-DSE**

Semester : V

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question no. 1 is compulsory.
4. **All** questions carry equal marks.
5. Use of Scientific Calculator is allowed.

1. Attempt any **five** of the following : (3×5=15)

(i) Show that the nuclear density is independent of the mass number A. How can it be concluded that nuclear density is very high?

P.T.O.

- (ii) What are the nuclear magic numbers? State the two basic assumptions of nuclear shell model.
 - (iii) A certain radioactive element disintegrates for an interval of time equals to its mean life. What is the remaining fraction that does not disintegrate?
 - (iv) Compare the photoelectric effect and Compton scattering in terms of the interactions between the incident photons and the target matters.
 - (v) What are the advantages offered by the semiconductor detectors over gas filled or scintillation detectors?
 - (vi) Why are the cyclotrons cannot be used to accelerate electrons? For a cyclotron, the r.f. potential applied across the dees is 20 KV and magnetic field of 1.10 T. If the maximum kinetic energy acquired by the protons is 4.56 MeV, then find radius of the dees.
 - (vii) Find the strangeness and hypercharge of a neutral elementary particle whose isotopic spin projection is $\frac{1}{2}$ and baryon number is +1.
2. (a) Discuss Rutherford's α -scattering experiment for the estimation of the nuclear size. Using the presently accepted empirical nuclear radius formula, determine the ratio of the nuclear radii of ${}^4_2\text{H}$ and ${}^{238}_{92}\text{U}$. (3+2=5)

- (b) Define the binding energy (BE) and average binding energy (BE/A) of a nucleon. Draw the average binding energy versus mass number curve. Write the main features of this curve.

(4+2+4=10)

3. (a) Explain the concept of nuclear force. Why is the surface term more significant for the lighter nuclei in the liquid drop model?

(3+2=5)

- (b) Write the semi-empirical binding-energy formula and obtain the expression of the atomic number Z_0 , the most stable isobar for a given mass number A . Identify the most stable isobar from the given isobars: ${}^6\text{He}_2$, ${}^6\text{Be}_4$ and ${}^6\text{Li}_3$.

(Given, $a_3 = 0.7053\text{MeV}$, $a_4 = 23.702\text{ MeV}$)

(2+7+1=10)

4. (a) Establish the relation between the mass of the parent atom and the mass of the daughter atom for the spontaneous positron emission. State the three differences of the electron capture from positron emission.

(2+3=5)

- (b) Explain how the alpha decay process is a quantum phenomenon. Write the decay equation of ${}^{222}_{86}\text{Rn}$ to ${}^{218}_{84}\text{Po}$ with the emission of α -particle. Calculate the Q value of the decay and the kinetic energy of the α -particle in MeV.

(4+1+5=10)

P.T.O.

5. (a) Why are the deuterons and neutrons used as bombarding agents in nuclear reactions? Write one each of deuteron induced and neutron induced nuclear reaction. (3+2=5)
- (b) What is the significance of nuclear reaction cross section? The cross-section and the number of atoms per cubic meter of Cd^{113} for capturing thermal neutrons are $2 \times 10^{-24} \text{ m}^2$ and $5.58 \times 10^{27} \text{ atoms/m}^3$. What thickness of Cd^{113} is needed to absorb 99% of the incident beam of thermal neutrons? Is Cd^{113} an efficient absorber of thermal neutrons? (3+6+1=10)
6. (a) How are the elementary particles divided into two main categories? Distinguish between baryons and mesons. (1+4=5)
- (b) Give the qualitative description of Quark model of elementary particles. Write down the quark contents of protons, neutrons and pions. (5+5=10)

Useful data:

$r_0 = 1.4 \text{ fm}$, mass of the proton = $1.67 \times 10^{-27} \text{ kg}$, $M({}_2^4\text{He}) = 4.0028 \text{ amu}$, $M({}_{86}^{222}\text{Rn}) = 222.017531 \text{ amu}$ and $M({}_{84}^{218}\text{Po}) = 218.008930 \text{ amu}$

5981 23/12/24

Examination Roll No.
 S. No. of Question Paper :
 Unique Paper Code :
 Name of Paper : **Astronomy and Astrophysics**
 Name of the Course : **B. Sc. (H) Physics – DSE**
 Semester : **V**

Duration: 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all including Question 1 which is compulsory.

Q1. Attempt any **five** questions:

(5 x 3)

- (a) Define the components of Geographical coordinates with the help of a relevant diagram.
- (b) Name the different spectral classes in which stars are classified. How does the temperature of stars vary from early type to late type.
- (c) Which transition in HI produces a low energy phonon of wavelength of 21-cm and name the telescope which is used to detect signal of this wavelength.
- (d) What is the diffraction limit of resolution of a 20 cm telescope. For wavelength of 500 nm ?
- (e) Why does the temperature in the chromosphere increases with height?
- (f) State Hubble Law. A galaxy has a recessional velocity of 19250 m/s. What is the distance of the Galaxy. Given that $H_0 = 70 \text{ km/s/Mpc}$.

Q2.(a) Explain at least two methods to estimate the stellar radii.

(5)

- (b) (i) Define proper motion of a star. How is it different from the radial motion of a star.
- (ii) Derive an expression for proper motion of star

$$V_p = 4.74 \times \theta \times r$$

where V_p is in Km/s and θ is in arc-sec per year and r is in parsec.

(3, 3)

(c) A star is brought from 40 pc to 5 pc. Calculate the change in its magnitude.

(4)

Q3. (a) Define the elements and angles of the Horizon coordinates system and show them on an appropriate diagram.

(8)

(b) Coordinates of stars A and B in the Universal Equatorial System are as follows: Right ascension $\alpha_A = 10^h$, declination $\delta_A = 70^\circ$ and $\alpha_B = 11^h$, $\delta_B = 80^\circ$ respectively, where α is the right ascension and δ is the declination of a star. Find the distance between the two stars.

(7)

Q4. (a) A giant refracting telescope at an observatory has an objective lens of focal length 15m. If an eyepiece of focal length 1.0 cm is used, what is the angular magnification of the telescope in normal adjustment. If this telescope is used

to view moon, what is the diameter of the image of the moon formed by the objective lens ? The diameter of the moon is $3.48 \times 10^6 \text{ m}$ and the radius of the lunar orbit is $3.8 \times 10^8 \text{ m}$. (5)

(b) Calculate the apparent magnitude of a Binary star (system of two stars). Given that the individual apparent magnitude of two stars are 1.0 and 2.0. (5)

(c) What are optical telescopes. Explain different types of optical telescopes, including their relative advantages and disadvantages. (5)

Q5. (a) Using Maxwell's equations, derive the following expression for magnetohydrodynamics

$$\frac{\partial \vec{B}}{\partial t} = \vec{\nabla} \times (\vec{v} \times \vec{B}) + \eta \nabla^2 \vec{B}$$

where the symbols have the usual meaning. (8)

(b) Explain the physical significance of magnetic Reynold number. (2)

(c) Draw labeled Hertzsprung-Russell (H-R) diagram. Write at least three features of H-R diagram. (5)

Q6. (a) Draw Rotation curve for a galaxy and discuss how it explains the concept of dark mass. (8)

(b) In the center of our galaxy, in the intense radio source Sgr A*, there is a black hole with large mass. A team of astronomers measured the angular distance of a star from Sgr A* and its orbital period around it. The angular distance was $0.12''$ and the period was 15 years. Distance between the center of the Milky Way galaxy and the Earth is 8.5 Kpc. Calculate the mass of black hole in terms solar mass. (7)

Q7. (a) Explain how the Cepheid variables are used to estimate astronomical distances. (5)

(b) State and derive Virial theorem for N body system. (7)

(c) Use Virial theorem to estimate the mass of a galaxy cluster whose radius is $R = 2.2 \text{ pc}$ and $\sqrt{\langle v_r^2 \rangle} = 1008 \text{ m/s}$, where v_r is the radial velocity. (3)

Table of Constants:

Mass of Sun	$M_{\odot} = 2 \times 10^{30} kg$
Radius of Sun	$R_{\odot} = 7 \times 10^8 m$
Temperature of Sun	$T_{\odot} = 5800 K$
Luminosity of Sun	$L_{\odot} = 4 \times 10^{26} W$
Solar Constant	$S = 1400 m/m^2$
Boltzmann Constant	$K_B = 1.38 \times 10^{-23} J/K$
Gravitational Constant	$G = 6.6 \times 10^{-11} Nm^2 Kg^{-2}$
Hubble Constant	$H_0 = 70 Km / s / Mpc$

Conversions:

$$1AU = 1.5 \times 10^{11} m$$

$$1Ly = 9.46 \times 10^{15} m$$

$$1pc = 3 \times 10^{16} m$$

6095 26/12/24

Nuclear and Particle Physics: C-1-15

Unique Paper Code : 32227504
Name of the Paper : Nuclear and Particle Physics
Name of the Course : B.Sc. (Hons.) Physics-CBCS-DSE
Semester : V
Duration : 3 hours
Maximum Marks : 75 Marks

Instructions for Candidates

(Write your Roll No. on the top immediately on receipt of this question paper).

Attempt five questions in all. Question no.1 is compulsory.

All questions carry equal marks.

Use of Scientific Calculator is allowed.

Q1. Attempt any five of the following:

3×5=15

- (i) Determine the ratio of nuclear radii of ${}^4_2\text{He}$ and ${}^{238}_{92}\text{U}$.
 - (ii) What is pairing effect? Why are even-even nuclei more stable as compared to even-odd and odd-odd nuclei?
 - (iii) The atomic ratio between the uranium isotopes ${}^{238}\text{U}$ and ${}^{234}\text{U}$ in a mineral sample is found to be 1.8×10^4 . The half life of ${}^{234}\text{U}$ is 2.5×10^5 years. Find half life of ${}^{238}\text{U}$.
 - (iv) Give any three characteristics of a nuclear force.
 - (v) Define the self quenching action of a GM counter.
 - (vi) Find out if ${}^{236}_{94}\text{Po}$ is stable or unstable against alpha decay. Atomic masses are given as follows: $M[{}^{236}_{94}\text{Po}] = 236.046 \text{ u}$, $M[{}^{232}_{92}\text{U}] = 232.03717 \text{ u}$, $M[{}^4_2\text{He}] = 4.0026 \text{ u}$.
 - (vii) Mention two differences between fermions and bosons. Give one example of each kind of particle.
2. If the energy of the α -particle emitted by ${}^{241}\text{Am}$ is 5.48 MeV. Find the closest distance it can approach an Au nucleus. 5

Define the mass defect and the binding energy (BE) of the nucleus. Represent graphically the variation of average binding energy per nucleon with the mass number A and labelled with its different regions. Give any two important conclusions which you can draw from this plot. 4+4+2=10

3. What are the magic numbers? Give any three experimental evidences for the existence of magic numbers. 2+3=5

Use the semi-empirical mass formula to find the atomic number (Z) for the most stable isobar nucleus of mass number, A . (Given coulomb coefficient, $a_3=0.7053\text{MeV}$ and asymmetry energy coefficient, $a_4=23.702\text{MeV}$). Identify the most stable isobar for $A=238$. 7+3=10

4. What conservation laws were apparently being violated in the observed continuous β spectrum? How did it help Pauli in predicting the nature of the new particle? 3+2=5

What are the basic assumptions of Gamow's theory of alpha decay? Discuss the Geiger-Nuttall law and draw the graphs obtained for different radioactive series in accordance with this law. 4+6=10

5. What are direct and compound-nucleus reactions? Give three main differences between direct and compound-nucleus reactions. 2+3=5

What is the working principle of a linear accelerator? What would be the length of the n^{th} drift tube in a linear accelerator operating at frequency ' f ' and employed to accelerate ions having charge ' q ' and mass ' m '? 2+8=10

6. What are muons? Show that muons' decay conserves the lepton number. 2+3=5

Describe the principle and working of an ionization chamber. The charged particles, of energy 4.18 MeV, are completely stopped in an ionization chamber. Calculate the number of ion pairs formed and the pulse voltage, given that the energy required to produce one ion pair is 35 eV and the capacitance of the chamber is 25 pF. 6+2+2=10

PHYSICAL CONSTANTS

$$m_p = 1.007825 \text{ u}$$

$$m_e = 0.00055 \text{ u}$$

$$R_0 = 1.2 \text{ fm}$$

$$h = 6.6 \times 10^{-34} \text{ Js}$$

$$1\text{eV} = 1.6 \times 10^{-19} \text{ J}$$

$$m_n = 1.008665 \text{ u}$$

$$1\text{amu} = 1.66 \times 10^{-27} \text{ kg}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$$

$$c = 3 \times 10^8 \text{ m/s}$$



7923

01/01/2025

Unique Paper Code : 2223010013
Name of the Paper : Astronomy and Astrophysics (DSE Paper)
Name of the Course : B.Sc. Hons.-(Physics)_NEP: UGCF-2022
Semester : V
Duration : 3 hours
Maximum Marks : 90

Instructions for Candidates

1. Write your Roll on the top immediately on receipt of this question paper.
 2. Attempt five questions in all.
 3. Question No. 1 is compulsory.
 4. Use of non-programmable scientific calculators is allowed.
-
1. Attempt any six of the following:
 - (a) Show the location of the Sun on Winter Solstice (Dec 21-22) in a diagram of equatorial coordinate system. What are Sun's declination and right ascension on this day? –
 - (b) Draw the night tracks of stars for an observer at Equator. Show the track of the Sun on Summer solstice for this observer, and locate the position of the sunrise and sunset on her horizon.
 - (c) If the minimum measurable parallax angle for a certain instrument is 10 arcseconds, what is the maximum distance at which the instrument can measure an object's parallax if (a) the baseline is equal to the Earth's diameter about 12,500 km and (b) the baseline is diameter of the Earth's orbit.
 - (d) The brightest stars are around 10^5 times brighter than the Sun. If the apparent magnitude of these bright stars in a galaxy is 22.5, how far away is the galaxy?
 - (e) The apparent diameter of the Sun is 32' (arc-minutes) and the flux of solar radiation received on the Earth is 1370 W/m^2 . What is the flux density at the surface of the Sun?
 - (f) Determine the value of α in the density profile ($\rho(r) \propto r^\alpha$) for a spherically symmetric mass distribution in a flat rotation curve.

(g) Given that a globular cluster is 14 Gyr old, what is the upper limit on the Hubble constant in units of $\text{kms}^{-1}\text{Mpc}^{-1}$, assuming that the rate of expansion of the Universe has remained constant?

(3 × 6 = 18)

2. a) Define the elements and coordinate angles of the horizon coordinate system. Draw a diagram showing the horizon coordinate system of an observer located at Delhi (30°N).
- (b) Show the hour angle of a star X on the local equatorial coordinate system of an observer at latitude ϕ . The local sidereal time (LST) is defined as the hour angle of the vernal equinox. Prove that for a star X, $\text{HAX} = \text{LST} - \text{RAX}$, where HAX is the hour angle of X and RAX is its right ascension.
- (c) What are circumpolar stars? A star has declination $\delta = 40^\circ$. If it is viewed from a point on the Arctic Circle (66.7°N) what are its maximum and minimum zenith distances?

(6, 8, 4)

3. (a) The shadow of a 2 m tall pole at a place is 1 m on the noon of winter solstice, when the Sun is at its highest point in the sky. What is the latitude of the place?
- (b) Discuss the classification of stars based on their temperature and luminosity. Draw the main sequence, red giant and super giant branches on an HR-diagram. Why are He lines prominent in O type stars and absent in K type stars?
- (c) Draw the cosmic distance ladder. What are type Ia supernovae and how are they used to estimate astronomical distances?

(6, 6, 6)

4. (a) The Sirius is a visual binary star system with components Sirius A and Sirius B. It has annual parallax of $0.38''$ (arcsec). The largest parallax of the separation between the two components is $12''$, and the minimum is $3''$. What is the semi-major axis and eccentricity of the relative orbit? The orbital period is found to be 50 years. What is the total mass of the system? If the semi-major axis of the orbit of Sirius B is double of that of Sirius A, find values of their individual masses.
- (b) Discuss the different observational properties of visual, spectroscopic and eclipsing binary star systems. How do these properties help determine stellar masses and radii? Why is the number of visual and eclipsing binaries observed very small compared to spectroscopic binaries?
- (b) Suppose the sun swells to 200 times its present radius while its surface temperature becomes half. Calculate its luminosity in terms of its present luminosity.

(8, 6, 4)

5. (a) Show that the magnetic flux is frozen with the hot plasma of large bodies like stars. How does this explain the very high temperature of the Sun's Corona relative to lower layers of its atmosphere.

(b) Discuss the internal structure of the Sun, with respect to energy generation and transmission. What is the evidence that convection is the chief form of energy transport below its surface?

(c) Give a description of the following with respect to their main properties like size, density, temperature, and the properties of radiation emitted.

(i) photosphere (ii) sun spots (iii) chromosphere , and (iv) Corona.

(10,4,4)

6. (a) Explain the meaning of scale factor $R(t)$ as defined in cosmology. Starting from Newtonian cosmology, derive the Friedmann equation in terms of scale factor. Show that for a flat universe, the scale factor evolves with time (t) as $R(t) \propto t^{2/3}$.

(b) Explain any one indirect evidence which supports the existence of dark matter in our universe.

(c) A globular cluster contains 100,000 stars of $1M_{\odot}$ each within a radius of 20 pc. Use virial theorem to estimate the average velocity of stars assuming that the average distance between them equals the radius of the cluster.

(10, 4, 4)

Useful Constants

$$G = 6.67 \times 10^{-11} \text{ m}^3\text{kg}^{-1}\text{s}^{-2}$$

$$k_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

$$\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$$

$$M_{\odot} = 1.99 \times 10^{30} \text{ kg}$$

$$R_{\odot} = 6.96 \times 10^8 \text{ m}$$

$$\text{AU} = 1.50 \times 10^{11} \text{ m}$$