B.Sc. 5th Semester (Honours) Examination, 2023 (CBCS)

Subject : Physics

Course : DSE-1

(Advanced Mathematical Physics)

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

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

1. Answer *any five* questions: 2×5=10

(a) For two matrices A and B, if $AB = BA$, show that $(AB)^n = A^n B^n$.

(b) Prove that Anti-Hermitian matrices have pure imaginary or zero eigenvalues.

(c) State the Cayley-Hamilton theorem for square matrix.

(d) Find a vector parallel to xy-plane and perpendicular to $4\hat{\imath} - 3\hat{\jmath} + \hat{k}$.

(e) Give two examples of physical quantities which are Tensor of Rank 1 and Tensor of Rank 2.

(f) Obtain the metric tensor g_{ij} for two-dimensional plane polar coordinates.

(g) Express the components of a cross-product vector $\vec{C} = \vec{A} \times \vec{B}$ in terms of ϵ_{ijk} and the components of $\vec{A}$ and $\vec{B}$.

(h) Expand the term of Tensor $S = a_{mn}x^m x^n$, taking $(m, n = 1, 2, 3)$

2. Answer *any two* questions: 5×2=10

(a) Let (x, y) denote coordinates in a rectangular Cartesian coordinate systems S and (x', y') denote coordinates in coordinate systems S', related by the equations

$$x' = 2x + 3y$$

$$y' = -3x + 4y.$$

Then find the area element in S' system which was $dxdy$ in S frame.

(b) If H is a Hermitian matrix and I is a unit matrix, determine whether P is a unitary matrix or not. Here $P = (I - iH)(I + iH)^{-1}$

(c) Prove that there is no distribution between contravariant and covariant vectors if the transformation law is of the form

$$\bar{x}^i = a^i_m x^m + b^i$$

Given all the a's and b's are constants such that $a^i_r a^i_m = \delta^r_m$.

(d) Given $A_k = \frac{1}{2}\epsilon_{ijk}B^{ij}$ with B^{ij} anti-symmetric. Then show that $B^{mn} = \epsilon^{mnk}A_k$.

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

(a) Let us consider a vector space defined by two orthogonal vectors $\vec{g} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ and $\vec{e} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$.

There are two matrices σ^+ and σ^- which acts on these vectors obeying the following rules:

$\sigma^+\vec{g} = \vec{e}, \quad \sigma^+\vec{e} = 0, \quad \sigma^-\vec{e} = \vec{g}, \quad \sigma^-\vec{g} = 0$

Find the 2×2 matrix form of these matrix-operators σ^+ and σ^-. Find the eigenvalues of a new matrix σ^z which is defined as $\sigma^z = \sigma^+\sigma^- - \sigma^-\sigma^+$. 6+4

(b) Find the eigenvalues and normalized eigenvectors of the matrix $B = \begin{pmatrix} 1 & 0 & 3 \\ 3 & 1 & 3 \\ 6 & 0 & 4 \end{pmatrix}$.

Now use the normalized eigenvectors to construct a unitary matrix and show that this matrix diagonalises the matrix B. 5+5

(c) How do you define inner product of two tensors? Let A^{pq}_{rst} be a tensor; choose $p = t$ and $q = s$ and show that A^{pq}_{rqp} is also a tensor. What is its rank? 2+6+2

(d) In Minkowski space we define $x_1 = x, x_2 = y, x_3 = z$ and $x_0 = ct$. This is done so that the space time interval can be defined as $ds^2 = dx_0^2 - dx_1^2 - dx_2^2 - dx_3^2$, here c is speed of light. Show that the metric in Minkowski space is

$$g_{ij} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}.$$

B.Sc. 5th Semester (Honours) Examination, 2023 (CBCS)

Subject : Physics

Course : DSE-1 (OR)

(Medical Physics)

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

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

1. Answer *any five* questions: 2×5=10

(a) What is electromyography (EMG)?

(b) Find out the degrees of freedom in case of upper human limb.

(c) Give examples of axial and appendicular skeletons in human body.

(d) What is external beam radiotherapy (EBRT)?

(e) Calculate the mean arterial pressure (MAP) of a person, while the output of BP measurement is 120/80.

(f) What do you mean by 'visual field loss' in case of glaucoma?

(g) Determine the action time and resting time of heart muscle when the heart rate is 90 pulses/min.

(h) What is loudness? Write down the physical quantities behind the perception "loudness".

2. Answer *any two* questions: 5×2=10

(a) Describe the basic principle of Electrocardiography (ECG)? Hence define P, Q, R, S and T (with proper schematic diagram) in case of a typical normal signal recorded between two electrodes. 1+4

(b) What are the main components of Central Nervous System (CNS)? Draw the electrical circuit analogus to a small axon and find out the energy required to recharge 500 mm length of non-myelinated axon, where $C = 3 \times 1\,0^{-7}$ F/m. 1+4

(c) Write down short notes on *any two*: 2½×2=5

(i) Nuclear Medicine

(ii) Dosimeter

(iii) Computed Tomography Scan

(d) Define intraocular pressure in case of a human eye. Calculate the force at intraocular region of a human being suffering from glaucoma (eye pressure 85 mm Hg), where the back area of her/his eye is 6 cm^2. 1+4

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

(a) Define anatomic plane in human body. Briefly describe the major anatomical planes. State the four levels of integration in the neuromusculo-skeletal system. Hence, describe human elbow as a class-3 lever. 1+2+3+4

(b) What is total peripheral resistance (TPR) to flow (blood flow in case of human body) and cardiac output (CO)? Calculate the cardiac output when TPR is 600 and BP is 80/60. Hence find the clinical significance of this result. 3+4+3

(c) Describe the basic principle of an ionisation chamber. If, α-particles (energy of which is 9MeV) looses their energy completely while passing through an ionisation chamber, then calculate the output voltage. What is characteristic X-ray spectrum? The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. Find the number of electrons striking the target (at every second). 2+4+1+3

(d) What is basal metabolic rate? Find the metabolic rate (at rest) of a 70 kg human being (height-1.55 m), while the energy consumption is 40 cal/m^2-hr. The sound intensity of a sound source is $7 \times 10^{-6} w/m^2$. If the loudness of sound is decreased by 10 dB, determine the intensity of sound. 2+5+3

———

B.Sc. 5th Semester (Honours) Examination, 2023 (CBCS)

Subject : Physics

Course : DSE-1 (OR)

(Nanomaterials and Applications)

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

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

1. Answer *any five* of the following questions: 2×5=10

(a) Bulk gold is yellow but nano gold is never yellow. — Why is it so?

(b) Write down the advantages of electrodeposition method.

(c) Can X-ray diffraction distinguish between C and N atoms? Explain.

(d) What are the primary differences between SEM and TEM?

(e) Distinguish between electrical band gap and optical band gap.

(f) What is a quantum dot? Why are quantum dots referred to as artificial atoms?

(g) What is an exciton? In which way it is different from polaron?

(h) What are the important applications of carbon nanotubes?

2. Answer *any two* of the following questions: 5×2=10

(a) What are the conditions of quantum confinement? An electron of energy 342 eV is confined in a one-dimensional box of length 1Å. Calculate (i) the quantum number 'n' of the energy state of the electron and (ii) the energy required to take the electron to the next higher state. 2+3

(b) What is Chemical Vapour Deposition (CVD) technique for thin film preparation? What are the different CVD techniques? State some uses of CVD. 1+2+2

(c) What is meant by the point defects in crystals? State the difference between Schottky and Frenkel defects. Which of these two changes the density of the solids? 2+2+1

(d) What are the basic differences between NEMS and MEMS? Write some of the applications of MEMS in medical science. 3+2

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

(a) (i) Distinguish between top down and bottom up approach for nanomaterial synthesis. Give examples in each case.

(ii) Describe sol-gel process for deposition of thin films. What are advantages and disadvantages of sol-gel process? 3+(5+2)

(b) Describe, in detail, about the principle and process of X-ray diffraction technique with neat sketch. X-rays of wavelength 0.71Å are reflected from the (111) plane of a NaCl crystal of lattice constant $a = 2.82$Å. Calculate the corresponding glancing angle for 2nd order reflection. 7+3

(c) What is a transmission electron microscope (TEM)? Describe briefly different modes of operation of TEM. What type of information a TEM can provide about the sample? 2+6+2

(d) (i) Discuss briefly the major applications of quantum dots in solar cells. What are advantages and disadvantages of quantum dot solar cell?

(ii) Describe briefly the applications of nanoparticle in medical science. What are advantages of using nanoparticles in drug delivery? 5+5

———