Time: 2 Hours   Full Marks: 40

The questions are of equal value. Candidates are required to give their answers in their own words as far as practicable. You must define all the symbols you use.

Answer any eight questions   5 x 8 = 40

1. (a) Show that (0, 0, 1), (1, 1, 1) and (2, 2, 1) are linearly dependent vectors whereas (1, 0, 0), (0, 1, 0) and (0, 0, 1) are linearly independent set of vectors.
   (b) Show that the polynomials $1+x$, $1-x$ and x^2 are three linearly independent functions. Also show that $(1/2)(3x^2 - 1)$ can be written as a linear combination of these three functions.

2. Take $|\gamma\rangle = |\beta\rangle - \dfrac{\langle \alpha|\beta\rangle}{\langle \alpha|\alpha\rangle}\, |\alpha\rangle$ where $|\alpha >$ and $|\beta>$ are two arbitrary vectors and use the fact that $<\gamma\,|\,\gamma \geq 0$. Then prove that $|\langle \alpha|\beta\rangle|^2 \leq \langle \alpha|\alpha\rangle\langle \beta|\beta\rangle$.

3. Determine the eigenvalues of the matrix:
$$\begin{pmatrix} a & 3 & 0 \\ 3 & 2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

4. Given two matrices A and B and their column vectors **a** and **b** :
$$A = \begin{pmatrix} -1 & 1 & i \\ 2 & 0 & 3 \\ 2i & -2i & 2 \end{pmatrix} \quad B = \begin{pmatrix} 2 & 0 & -i \\ 0 & 1 & 0 \\ i & 3 & 2 \end{pmatrix}$$
$$\vec{a} = \begin{pmatrix} i \\ 2 \\ 2 \end{pmatrix} \qquad \vec{b} = \begin{pmatrix} 2 \\ 1-i \\ 0 \end{pmatrix}.$$

   Then find (i) $A\vec{a}$ (ii) $\vec{a}^{\,\dagger}\,\vec{b}$ (iii) $\vec{a}^{\,T} B\, \vec{b}$ (iv) $\vec{a}\,\vec{b}^{\,\dagger}$ (v) $B\vec{b}$.
   Here transpose is denoted by the symbol T and hermitian conjugate is denoted by dagger † sign.

5. Solve the differential equation
$$\frac{d}{dt}\vec{X} = A\,\vec{X}$$

$$\vec{X} = \begin{pmatrix} x(t) \\ y(t) \end{pmatrix} \qquad\qquad A = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$$

Where and

Given initial conditions are $x(t = 0) = x_0$ and $y(t = 0) = y_0$.

6. Define Pure Strain Tensor ε_{ij} . Prove that it is a symmetric tensor of rank 2. Also give Physical significance of its components ϵ_{11} and ϵ_{12}

7. The kinetic energy and contravariant components of acceleration of a particle of constant mass M are given respectively as

$$T = \frac{1}{2} Mg_{pq} \dot{x}^p \dot{x}^q; \quad and \quad a^k = \frac{d^2 x^k}{dt^2} + \{^k_{pq}\} \frac{dx^p}{dt} \frac{dx^q}{dt}$$

Prove that

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{x}^k}\right) - \frac{\partial T}{\partial x^k} = Ma_k$$

8. If $a_{ij} x^i x^j = 0$ for all values of the independent variables $x^1, x^2 \ldots\ldots x^n$ and a_{ij} are constants, then show that

$$a_{pq} + a_{qp} = 0$$

9. (a) Define magnitude or length of a tensor of rank one.

(b) Show that if λ_i and μ^i are the components of a covariant and contravariant vector respectively, then the sum if $\lambda_i \mu^i$ is an invariant.

10. Prove that eigenvectors corresponding to distinct eigenvalues of a symmetric second rank tensor are orthogonal. [You may use bra-ket notation of matrix algebra to prove this.]

B.Sc. Semester-V (Honours) Examination, 2022 (CBCS)
Subject: Physics
Paper: DSE-1 (Medical Physics)

Time: 2 Hours   Full Marks: 40

The questions are of equal value. Candidates are required to give their answers in their own words as far as practicable. You must define all the symbols you use.

Answer any eight questions   5 x 8 = 40

1. What is loudness? Write down the physical quantities behind the perception "loudness". The sound intensity of a source of sound is 6×10^{-6} W/m^2. If the sound intensity level is increased by 10 dB, determine the intensity of sound.

2. Define these two types of joint movements: Flexion and Extension. Hence write down the muscles involved in these movements.

3. What is a motor nerve? Determine the pulse speed along the motor nerve axons if the delay time between two consecutive signals is 4 ms.

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

5. Discuss about the two types of photo receptor cells in human eye. What is *fovea centralis*? What strength of a corrective lens is required in case of a myopic eye, which has a far point of 1m.

6. What is characteristic x-ray spectrum? Find the critical voltage that must be applied to an X-ray tube to excite the *K*-series of a copper target. Where the *K*-absorption limit is 1.380 $\mathring{A}$ for copper.

7. Write short notes on any two: (i) Gamma Knife. (ii) Nuclear Medicine and (iii) Endoscopy.

8. State the basic principle of an ionisation chamber. If α-particles (energy of which is 9 *MeV)* looses their energy completely while passing through an ionisation chamber, then calculate the output voltage pulse.

9. What is MRI? How the image contrast can be enhanced in case of MRI?

10. What are ECG and EEG? State the basic difference between these two.