B. Sc. V Semester (Honours) Examination, 2020 (CBCS)
Subject: Physics
Paper - DSE-1: (1) ADVANCED MATHEMATICAL PHYSICS

Time: 2 Hours Full Marks: 40

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

Answer any 08 (eight) out of 10 (ten) questions carrying 05 marks each: 8 x 5 = 40

1. (a) Define inner product of two vectors?
   (b) Consider two dimensional real space with basis vectors: $\hat{u}_1$ = (1, 2) and $\hat{u}_2$ = (4, 7). Write down the vector $\vec{v}$ = (5, 8) in terms of this basis set.
   (c) If angular momentum vector $\vec{L}$ is not parallel to angular velocity vector $\vec{\omega}$, what can you say about the moment of Inertia **I** from the equation $\vec{L} = \mathbf{I}\,\vec{\omega}$.

2. Find the anti-symmetric matrix associated with the vector $\vec{v}$ = (2, −3, 1).

3. (a) If |X> is eigenvector of Hermitian operator $\hat{H}$ and another vector |Y> is orthogonal to |X>, then show that H |Y> is orthogonal to |X>.
   (b) Trace of a 2 × 2 matrix M is 4 and determinant of matrix M is 8. One eigenvalue of the matrix is 2(1 + i), then what is the value of the other eigenvalue?

4. Consider the second order differential equation

$$\frac{d^2x}{dt^2} + \frac{dx}{dt} - 12x = 0$$

   (a) Write the above equation as two coupled linear first order differential equations.
   (b) Solve the two coupled differential equations you wrote, using matrix method. The initial conditions are given as $x(t=0) = 0$ and $\left.\frac{dx}{dt}\right|_{t=0} = x'(t=0) = 8$.

5. Find the eigenvalues of the matrix B where

$$B = A - 3A^3 + 3A^2 - 2A + 8 \text{; and } A = \begin{bmatrix} 1 & -1 \\ 2 & 3 \end{bmatrix}$$

6. (a) Show that the velocity and acceleration vectors are contravariant vectors.
   (b) Show that div (curl $\vec{F}$) = 0 i.e., $\vec{\nabla}.\left(\vec{\nabla} \times \vec{F}\right) = 0$ for a vector $\vec{F}$ using tensor analysis.

7. If $\vec{q} = \vec{\omega} \times \vec{r}$ show that $\vec{\nabla} \times \vec{q} = 2\vec{\omega}$ using the index notation of tensor calculus. The vector $\vec{\omega}$ is a constant and $\vec{r}$ is position vector in 3D.

   [Use the identities $\varepsilon_{ijk}\varepsilon_{kmn} = \delta_{im}\delta_{jn} - \delta_{in}\delta_{jm}$ and $\delta_{kk} = 3$]

8. If $ds^2 = 3\,(dx^1)^2 + 5\,(dx^2)^2 - 3\,dx^1dx^2$, then find the matrices (i) $\left(g_{ij}\right)$ and (ii) $\left(g^{ij}\right)$ (The symbols have their usual meaning.)

9. Prove that moment of inertia is symmetric tensor of order two by writing down all the components of it, starting from the relation $\vec{L} = \vec{r} \times \vec{p}$. [Define all the symbols you use].

10. Prove that $\frac{\partial A_i}{\partial x^j}$ is not a tensor though A_i is a tensor of type (0,1).

OR

B.Sc. Semester V (Honours) Examination, 2020 (CBCS)
Subject: Physics
Course/Paper: DSE-1 (Medical Physics)

Time: 2 Hours Full Marks: 40

Candidates are requested to give their answer in their own words as far as practicable

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Answer any eight (8) of the following questions: (8×5=40)

1. Define anatomical plane in human body. Briefly describe the major anatomical planes. What is the degrees of freedom in case of upper human limb.

2. 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.

3. Give examples of axial and appendicular skeletons in human body. Describe human elbow (bio- mechanical musculoskeletal system) as a class 3 lever.

4. Write down the main components of eye focussing system in case of human eye. Find out the focal lengths (f_{front} and f_{back}) of cornea when, $n_{ah} = n_{vh} = 1.33$. (Radius of the cornea, R = 7.5 mm).

5. Define resting potential and action potential. Draw the electrical circuit analogues to a small axon, hence find out the energy required to recharge 1 meter length of nonmyelinated axon. Where $C = 3\times10^{-7}$ F/m.

6. What is the typical thickness of a visualized slice in case of any x-ray computerized tomography? State the basic differences between x-ray imaging and MRI and discus the advantages, if any.

7. Describe the basic working principle of electrocardiograph (ECG). Hence, define P, Q, R, S and T (with proper schematic wave diagram) in case of a typical normal signal recorded between two electrodes.

8. What is external beam radiotherapy (EBRT)? Write down the main sources of radiation in case of EBRT. What are the advantages of EBRT over brachytherapy?

9. Write down short notes (on any two): (i) Dosimeter, (ii) Ultrasound imaging (diagnostic sonography), (iii) Fluoroscopy.

10. What is bremsstrahlung? Calculate the wavelength of x-rays that undergoes second order reflection at 15^0 from the (100) face of a cubic crystal of *KCl*. Where, crystal density = 1.98 gm/cm^3 and Avogadro number = 6.02×10^{23}.