

M.Sc.(Maths.) Semester - 3 (CBCS) Examination**Nov/Dec-2023 (NEW COURSE)****Sp. Theory of Relativity and Tensor Analysis (Elective (New))****Time: 2:30 Hours****Marks: 70****Instructions:**

1. Figures to the right indicate marks.
2. All questions are compulsory.

- Que.1(A) Answer the following question. (04)
- 1) Explain the concept of Galilean Transformation in Newtonian Relativity. Provide an example.
- Que.1(B) Answer any Two out of Three. (10)
- 1) Describe the Michelson-Morley experiment and explain its significance for the development of Special Relativity.
 - 2) Show that Wave equation is not invariant under Galilean transformation.
 - 3) Two events P and Q occur simultaneously in S - frame. Are they simultaneous in S' - frame?
- Que.2(A) Answer the following question. (04)
- 1) Define length contraction and time dilation. Provide the mathematical expressions for both effects.
- Que.2(B) Answer any Two out of Three. (10)
- 1) Explain the equivalence of mass and energy in Special Relativity. Derive Einstein's famous equation, $E=mc^2$.
 - 2) A spaceship travels at a velocity of $0.9c$. Calculate the relativistic mass of the spaceship if its rest mass is 1000 kg.
 - 3) A spaceship is moving at $0.8c$ relative to Earth. Calculate the length contraction and time dilation experienced by the astronauts on the spaceship, compared to observers on Earth.
- Que.3(A) Answer the following question. (04)
- 1) Explain the concept of a vector field in affine space and Riemann space. How do they differ from vector fields in Euclidean space?
- Que.3(B) Answer any Two out of Three. (10)
- 1) Discuss the use of tensors in describing physical phenomena. Provide an example of a tensor that represents a physical quantity.
 - 2) Show that the sum of two co-variant vector is also a co-variant vector of same rank and the sum of two contra-variant vector is also a contra-variant vector of same rank.
 - 3) Define Symmetric tensor, Skew symmetric tensor, Inner product and Outer Product in tensor.
- Que.4(A) Answer the following question. (04)
- 1) Define Christoffel symbols and explain their role in Riemannian geometry.
- Que.4(B) Answer any Two out of Three. (10)
- 1) Calculate the Christoffel symbols for a 2-dimensional Riemannian space with a given metric tensor. Show your work step by step.
 - 2) Explain how Christoffel symbols are used in the context of covariant differentiation.
 - 3) Prove that $\Gamma_{\alpha\beta\delta} = \Gamma_{\beta\alpha\delta}$ and $\Gamma_{\alpha\delta\beta} \neq \Gamma_{\alpha\beta\delta}$.
- Que.5(A) Answer the following question. (04)
- 1) Explain Length contraction using Space-Time Diagram.
- Que.5(B) Answer any Two out of Three. (10)
- 1) Find inverse of Special Lorentz Transformation.
 - 2) Show that $g_{\mu\nu}$ is co-variant symmetric tensor of rank 2.
 - 3) Show that the laws of transformation of a contra-variant vector and co-variant vector forms a group.
