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63/2 (SEM-3) MAT 305

2022

(Held in 2023)

MATHEMATICS

(Theory Paper)

Paper Code : MAT-305

(Special Theory of Relativity)

Full Marks – 80

Pass Marks – 32

Time – Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : $1 \times 6 = 6$
- (a) Distinguish between the inertial and non-inertial frame of reference.
 - (b) What is the fourth-coordinate according to Minkowski ?
 - (c) Under which condition Lorentz transformation reduces to Galilean transformation ?

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- (d) What is the mass of an object if it approaches the speed of light?
- (e) What is the resultant of two velocities of light each of which is less than c ?
- (f) Length contraction happens in which direction?

2. Answer the following questions : $2 \times 5 = 10$

- (a) Which is invariant under Galilean transformation? What is the lowest possible mass of a particle?
- (b) What are the postulates of the special theory of relativity?
- (c) 'Simultaneity is not absolute' – justify.
- (d) What do you mean by Newtonian mechanics?
- (e) Mention Maxwell's electromagnetic equations.

3. Answer any *six* from the following questions :

$5 \times 6 = 30$

- (a) Establish the mass energy equivalence relation.
- (b) Enunciate the variation of mass with velocity.
- (c) Establish the Addition law of two velocities.
- (d) Show that $(ds)^2 = (dx)^2 + (dy)^2 + (dz)^2 - (cdt)^2$ is invariant under Lorentz transformation.

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- (e) Give the geometrical interpretation of simultaneity, time dilation, length contraction.
- (f) Prove that laws of electromagnetism are not invariant under Galilean transformation.
- (g) If u and v are two velocities in the same direction and V is their resultant velocity given by

$$\tan^{-1} \frac{V}{c} = \tan^{-1} \frac{u}{c} + \tan^{-1} \frac{v}{c}$$

then deduce the law of composition of velocities from this equation.

- (h) Explain briefly about four vectors and four velocities.
- (i) Prove that Lorentz transformation forms a group.

4. Answer any *two* from the following questions :

$10 \times 2 = 20$

- (i) What is Relativistic Lagrangian? Deduce Relativistic Lagrangian equations of motion.
- (ii) Explain briefly about Minkowski space. Deduce relativistic equations of motion.
- (iii) Discuss about invariance of Lorentz force equation.

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5. Answer any *one* of the following questions :
14×1=14

- (a) What is D'Alembert operator ? Deduce the transformation equations for differential operator and prove that it is invariant under Lorentz transformations.
- (b) Deduce the Lorentz transformations of electric field and magnetic field components and prove that Maxwell's equations are invariant under Lorentz transformations.