Mid Semester Examination (Even Semester) of M.Sc. III (Physics)

Question paper

Subject Code:PH-362

(Total marks: 30; Time-duration: From 11:30 am To 1:30 pm.; Date: March 11, 2022)

- **Question (1):**

(a)Write down fundamental postulates of the relativity theory. (Marks:1)

(b)Use the postulates of the relativity theory to derive the Lorentz transformation with the assumption that space and time are homogeneous. (Marks:2)

(c)Use Lorentz transformation to derive the following cosequences:
(i) A body's length is measured to be greatest when it is at rest relative to the observer. When it moves with velocity v relative to the observer its measured length is contracted in the direction of its motion by the factor $\sqrt{(}1 - v^2/c^2)$, whereas its dimensions perpendicular to the direction of motion are unaffected. (Marks:2)
(ii) A clock is measured to go at its fastest rate when it is at rest relative to the observer. When it moves with a velocity v relative to the observer, its rate is measured to have slowed down by a factor $\sqrt{(}1 - v^2/c^2)$. (Marks:2)

- **Question (2):**

(a)Use an appropriate approximation in the Lorentz transformation to obtain the Galilean transformation. (Marks:1)

(b) Show that the following physical laws, (i) Newton's second law of motion, (ii) the law of conservation of momentum and (iii) the law of conservation of energy are invariant to the Galilean transformation. (Marks: 2)

(c) The initial positions of two particles are $x_1 = 20.0 \quad cm$, $y_1 = 0.0$ and $x_2 = 0.0$, $y_2 = 20.0 \quad cm$ respectively. If the velocity of the first particle be $-5 \times 10^5 \hat{x}\ cm/s$, calculate velocity of the second at the instant that the two just collide with each other. what is then the relative velocity of the first particle with respect to the second ? (Marks:2)

- **Question (3):**

(a) Discuss the relativistic addition of velocities, particularly, obtain the transformation of velocities parallel to the direction of relative motion of the two frames of reference, and also for velocities that are perpendicular to the direction of relative motion. (Marks:3)

(b)Show that any velocity less than "c" relativistically added to "c" give a resultant "c". (Marks:1)

(c) In the laboratory two particles are observed to travel in opposite directions with speed $0.82c$. Deduce the relative speed of the particles. (Marks:1)

- **Question (4):**

Discuss the Michelson-Morley experiment. Your discussion should particularly include the following: an introduction of the experiment; a schematic diagram of the experiment; a theory involved in the experiment; a discussion; and the final conclusion of the experiment. (Marks:5)

- **Question (5):**

(a) Obtain the relativistic expression of kinetic energy and show that it tends to the classical expression if $v \ll c$. (Marks:2)

(b) Show that the four-dimensional volume element is invariant under the Lorentz

transformation. (Marks:1)

- **Question (6):**

  Obtain the below expression,

$$\frac{1}{\sqrt{1-u^2/c^2}} = \frac{1+u_x^{'}v/c^2}{\sqrt{1-u^{'2}/c^2}\sqrt{1-v^2/c^2}}$$

  In this expression, the physical quantities have their usual meanings. The primed and unprimed quantities correspond to their values in the $S^{'}$ and S inertial frames of reference, respectively. v is the velocity of $S^{'}$ inertial frame with respect to S frame of reference. "c" is the speed of light. (Marks:2)

- **Question (7):**

  Write down the components of the momentum 4− vector in S and $S^{'}$ inertial frames of reference, and obtain the following mathematical relations:

$$p_x = \frac{1}{\sqrt{1-v^2/c^2}}\left(p_x^{'} + \frac{E^{'}v}{c^2}\right)$$
$$E = \frac{1}{\sqrt{1-v^2/c^2}}\left(E^{'} + vp_x^{'}\right)$$

  The physical quantities that appear in the above expressions have their usual meaning. The primed and unprimed quantities correspond to their values in the $S^{'}$ and S inertial frames of reference, respectively. v is the velocity of $S^{'}$ inertial frame with respect to S frame of reference. "c" is the speed of light. (Marks:3)