I20PH007

Sardar Vallabhbhai National Institute of Technology, Surat 395007

Department of Physics

Mid-Sem Exam of M.Sc.- 3rd Year (Even Semester)

Basic Course on Relativity (PH 362)

(Total marks: 30; Time: 11:00 am to 12:30 pm; Date: March 11, 2023)

Attempt all questions!

1. Describe Michelson-Morley's experiment. Your description should include the following:
   (a) Purpose of the experiment.
   (b) Its schematic diagram.
   (c) A detailed analysis of the experiment.
   (d) Its conclusions.
   (Marks:6)

2. (a) Write the principles of the special theory of relativity and use them to derive the Lorentz transformation.
   (b) Apply an appropriate approximation to the Lorentz transformation to obtain the Gallilean transformation.
   (Marks:6)

3. Present "*gedanken (thought)*" experiments to explain the geometrical consequences of Einstein's postulates,
   (a) The relativity of simultaneity,
   (b) Time dilation and
   (c) Lorentz contraction
   (Marks:6)

4. (a) Obtain Einstein's formula for the addition of velocities.

(b) Show that when the velocity of light is added to the velocity of light, we get the velocity of light.

(Marks:6)

5. (a) What will be the apparent length of a meter stick measured by an observer at rest, when the stick is moving along its length with a velocity equal to $\sqrt{3}c/2$.

(b) Rockets A and B are observed from the earth to be travelling with velocities $0.8c$ and $0.7c$ in the same direction. What is the velocity of B as seen by an observer in A.

(Marks:4)

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Department of Physics

End-Sem Exam of M.Sc.- 3rd Year (Even Semester)

Basic Course on Relativity (PH 362)

(Time: 09:30 am to 12:30 pm; Total marks: 50; Date: May 05, 2023)

Attempt all questions!

1. (a) Show the universality of Newton's second law in all inertia frames.

   (b) Use the Lorentz transformation to understand the simultaneity aspects of two events in different inertial frames.

   (c) Use a space-time diagram to show time-dilation and length-contraction concepts.

   (d) What will be the apparent length of a meter stick measured by an observer at rest when the stick is moving along its length with a velocity equal to c.

   (Marks: 10)

2. Obtain the following relations:

   (a) $$\frac{1}{\sqrt{1-u^2/c^2}} = \frac{1+u'_x v/c^2}{\sqrt{1-u'^2/c^2}\sqrt{1-v^2/c^2}}$$

   (b) $$p_x = \frac{p'_x + E' v/c^2}{\sqrt{1-v^2/c^2}}$$

   (c) $$E = \frac{E' + v p'_x}{\sqrt{1-v^2/c^2}}$$

   (d) $$m' = \frac{m(1-vu_x/c^2)}{\sqrt{1-v^2/c^2}}$$

(c)

$$\frac{dE}{dp} = u$$

(Marks:10)

3. Show that current density 4- vector is divergenceless. (Marks:5)

4. Show that $c^2t^2 - (x^2 + y^2 + z^2)$ is an invariant quantity. Also show that the quantity $E^2/c^2 - (p_x^2 + p_y^2 + p_z^2)$ for a particle is an invariant. (Marks:5)

5. (a) Write the form of Field tensor $F^{\mu\nu}$ and dual tensor $G^{\mu\nu}$.

   (b) Express the Maxwell's equations in terms of $F^{\mu\nu}$ and $G^{\mu\nu}$, and use that form to obtain the following relations,

$$\vec{\nabla} \cdot \vec{E} = \rho/\epsilon_0$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

   (Marks:10)

6. (a) Derive the complete set of electromagnetic field transformation rules considering that the moving frames are directed along x- direction.

   (b) A parallel-plate capacitor, at rest in S_0 and tilted at a 45^0 angle to the x_0 axis, carries charge density $\pm\sigma_0$ on the two plates (Figure 1). System S is moving to the right at speed v relative to S_0.

      i. Find $\vec{E}_0$, the field in S_0.

      ii. Find $\vec{E}$, the field in S.

Fig-1

(Marks:10)