UNIVERSITY OF SRI JAYEWARDANEPURA - FACULTY OF APPLIED SCIENCES

B. Sc. General Degree Second Year Second Semester Course Unit Examination - **April/May, 2022**

DEPARTMENT OF PHYSICS

PHY 207 1.0 / PHY 257 1.0 / PHY 302 1.0 / PHY 327 1.0 - Special Theory of Relativity

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Time : One hour; No of Questions : 04; No of Pages : 02 & Total marks : 100

Answer all questions

Assume, velocity of light (c) = 3×10^8 ms^{-1}

01. Write down the **two** main Einstein's Postulates in Special Theory of Relativity (STR).

Obtain the following relativistic time equation, starting from the above postulates in STR.

$t^1 = \gamma\, t$, where, $\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$; (symbols have their usual meanings).

The mean lifetime of stationary muons is measured to be 2.20 ms. The mean lifetime of high-speed muons in a burst of cosmic rays observed from Earth is measured to be 16.0 ms. What is the speed of these cosmic-ray muons relative to Earth?

(25 Marks)

02. Derive an expression for the length contraction ($l_2 = l_1\sqrt{1 - v^2/c^2}$) starting from the relativistic time equation (Symbols have their usual meanings).

A rod lies parallel to the x axis of reference frame S, moving along this axis at a speed of 0.6 c. Its rest length is 2.0 m. What will be its measured length in frame S?

(25 Marks)

03.

Let us assume two objects **A** and **B** are moving in an opposite direction to each other with constant velocities $\mathbf{V_A}$ and $\mathbf{V_A}$ respectively. **Find the relative velocity** of B with respect to A, $V_{(B,A)}$ starting from the Lorentz velocity transformation equation.

A particle moves along the x^1 axis of frame S^1 with velocity 0.40 c. Frame S^1 moves with velocity 0.60 c with respect to frame S. What is the velocity of the particle with respect to frame S?

{You may assume that the Lorentz velocity transformation equation for the above case takes the following form;

$$U_x^1 = \frac{U_x - v}{1 - \frac{v}{c^2}U_x}.$$ *Where symbols have their usual meanings.}*

(25 Marks)

04. A spaceship, moving away from Earth at a speed of 0.9 c, reports back by transmitting a signal at a frequency (measured in the spaceship frame) of 100 MHz. **To what frequency** must Earth receivers be tuned to receive the report?

{*You may assume that the relationship between the observed frequency and the source frequency for the above case takes the following form;*

$$f_o = \frac{f_s}{\gamma\ \left(1 - \beta\ \cos\theta\right)}.$$

Where, $\gamma = 1/\sqrt{1-\beta^2}$, $\beta = \frac{v}{c}$ *and other symbols have their usual meanings.}*

(25 Marks)

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