UNIVERSITY OF SRI JAYEWARDANEPURA - FACULTY OF APPLIED SCIENCES

B. Sc. General Degree Second Year Second Semester Course Unit Examination – March/April, 2023

DEPARTMENT OF PHYSICS

PHY 207 1.0 - Special Theory of Relativity

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).

Your starship passes the Earth with a relative speed of 0.9c. After traveling 10.0 years (your time), you stop turn, and then travel back to the Earth with the same relative speed. The trip back takes another 10.0 years (your time).

How long does the round trip take according to measurements made on Earth? (Neglect any effects due to the accelerations involved with stopping, turning, and getting back up to speed.)

(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 meter stick in frame S^1 makes an angle of $30°$ with the x^1 axis. If that frame moves parallel to the x axis of frame S with speed 0.9 c relative to frame S, what is the length of the stick as measured from S ?

(25 Marks)

03. Galaxy A is reported to be receding from us with a speed of 0.35c. Galaxy B, located in precisely the opposite direction, is also found to be receding from us at this same speed.

What multiple of c gives the recessional speed an observer on Galaxy A would find for

(a) our galaxy and

(b) Galaxy B ?

{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 sodium light source moves in a horizontal circle at a constant speed of 0.1c while emitting light at the proper wavelength of λ_0 = 589 nm. Wavelength λ is measured for that light by a detector fixed at the center of the circle.

What is the wavelength shift $\lambda - \lambda_0$?

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

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

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

(25 Marks)

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