National Open University of Nigeria
Plot 91, Cadastral Zone, Nnamdi Azikiwe Expressway, Jabi - Abuja
Faculty of Sciences

Department of Pure and Applied Science

JANUARY 2018 Examination

COURSE CODE: PHY303
COURSE TITLE: Special Relativity
CREDIT UNIT: 2
TIME: 2 Hours:
INSTRUCTION: Answer question 1 and any three questions.

PHYSICAL CONSTANTS:
Speed of light $c = 2.9979\ ms^{-1}$; mass of electron $m_e = 9.11 \times 10^{-31} kg$;
Electronic charge $e = 1.6022 \times 10^{-19} C$; Avogadro's number $N_A = 6.0221 \times 10^{26} kmol^{-1}$;
Boltzmann constant $k = 1.3806 \times 10^{-23} JK^{-1}$; Plank's constant $h = 6.6257 \times 10^{-34} Js$;

QUESTION 1

(a) Derive the Lorentz velocity transformation for the x-axis. (8 marks)
(b) At what speeds will the Galilean and Lorentz expressions for u'_x differ by 2%? (7 marks)

QUESTION 2

A rocket ship 90 m long travels at a constant velocity of 0.8c relative to the ground. As the nose of the rocket ship passes a ground observer, the pilot in the nose of the ship shines a flashlight toward the tail of the ship. What time does the signal reach the tail of the ship as recorded by (a) the pilot, (b) the ground observer? (c) When does the tail of the rocket pass the ground observer according to the ground observer and (d) according to the pilot? (15 marks)

QUESTION 3

(a) The equation for a spherical pulse of light starting from the origin at t = t′ = 0 is

$x^2 + y^2 + z^2 - c^2t^2 = 0$. Show from the Lorentz trans- formations that O′ will also measure this same pulse to be spherical, in accord with Einstein's second postulate stating that the velocity of light is the same for all observers. (9 marks)

(b) Show that $dx^2 + dy^2 + dz^2 - c^2dt^2$ is invariant under the Lorentz transformation.

QUESTION 4

Show that the electromagnetic wave equation $\nabla^2\varphi - \frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}$ is invariant under the Lorentz transformation. (15 marks)

QUESTION 5

Pions have a half-life of 1.8×10^{-8}s. A pion beam leaves an accelerator at a speed of 0.8c.

(a) Classically, what is the expected distance over which half the pions should decay? (5 marks)

(b) Determine this distance relativistically. (10 marks)