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**NATIONAL OPEN UNIVERSITY OF NIGERIA**

**PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA**

**FACULTY OF SCIENCES**

**DEPARTMENT OF PURE AND APPLIED SCIENCE**

 **JULY 2018 EXAMINATIONS**

**COURSE CODE: PHY303**

**COURSE TITLE: SPECIAL RELATIVITY**

**CREDIT UNIT 2**

**TIME ALLOWED (2 HRS)**

**INSTRUCTION: *Answer question one (1) and any other three (3) questions***

**QUESTION 1**

1.(a)(i) What is time dilation in special relativity? **2 marks**

 (ii) Show how Lorentz transformation accounts for the contraction of bodies and retardation

 of clocks that are in motion. **4marks**

(b)(i) Muons (mu mesons) are unstable particles with an average life span of $2×10^{-9}s$ and

 speed of$ 2.994×10^{8} ms^{-1}$. They are created at altitudes of some thousands of kilometers

 in the atmosphere by cosmic rays incident upon the earth from outer space. With suitable

 calculations, explain why they are found on earth in profusion despite their short life span.

 **5marks**

 ii) An observer in a rocket measures its length as $10 m$ and orientation as $60°$ relative to the

 horizontal. Calculate the length and orientation of the rocket as it appears to a stationary

 observer on earth if the rocket’s speed is $\frac{\sqrt{3}}{2}c.$ **4 marks**

(c) Calculate the velocity of a proton whose kinetic energy is 200Mev. **4 marks**

(d) A particle moves with a speed of 0.8c at an angle of 30o to the x-axis, as determined by

 observer O. What is the velocity of the particle as determined by a second observer O’,

 moving with a speed of -0.6c along the common x-x’ axis. **6 marks**

**QUESTION 2**

(a) In a Michelson Morley experiment, an equal arm interferometer with arms

 10m and light of wavelength 600Ao was used. The expected number of fringes

 was 0.005. Calculate the velocity of the earth relative to ether. **4 marks**

(b)A passenger in a train moving at 30k/h passes a man standing on a station platform

 at t = t’ = 0.Twenty seconds after the train passes him, the man on the platform determines

 that a bird flying the tracks in the same direction as the train is 800m away. What is the

 average speed of the bird as determine by the man. **4 marks**

(c) The equation of an electromagnetic wave in free space is given as

$$\frac{∂^{2 }E\_{x}}{∂x^{2}}+\frac{∂^{2}E\_{x}}{∂y^{2}}+ \frac{∂^{2}E\_{x}}{∂z^{2}}= \frac{1}{c^{2}}\frac{∂^{2}E\_{x}}{∂t^{2}}$$

Show that this equation is not invariant under Galilean transformation.**7 marks**

**QUESTION 3**

 (a) A sample of radioactive material at rest in the laboratory ejects two electrons in opposite directions. One of the electron has a speed of 0.6c and the other has a speed of 0.7c, as measured by a laboratory observer. According to classical velocity transformations, what will be the speed of one electron as measured from the other **4 marks**

(b) A man in a boat moving at constant speed of 50km/h relative to the shore throws an object in the forward direction with a speed of 20.5km/h. What is the speed of the object as measured by an observer at rest at the shore. **4 marks**

 (c)(i) In a Michelson-Morley experiment, the lengths of the arms of the interferometer was

 found to be $11 m$ and the wavelength of light used was$ 6000 Å$. Calculate the total

 expected fringe shift when the apparatus is rotated through$ 90°$. Take the orbital speed of

 the earth to be $3×10^{4}ms^{-1}$. **4 marks**

 (ii) Briefly discuss two viewpoints that were suggested to retain the ether concept. **3 marks**

**QUESTION 4**

(a) Calculate the momentum of a 1Mev electron. [Hints: E2 = (pc)2 + Eo2] **3 marks**

(b) An observer at rest with respect to the ground observes the following collision. A particle

 mass M1= 1kg moving with velocity U1 = 4m/s along the axis approaches a second

 particle of mass M2 = 1kg moving with velocity U2= -3m/s along the X- axis. After a

 head on collision the ground observer finds that M2has a velocity U2 = 3m/s along the

 X- axis. Find the velocity U1 of M1 after collision. **4 marks**

 (c)(i) Write down the components of the electric and magnetic fields $\vec{E}^{'}$ and $\vec{B}^{'}$ in the $S^{'}$ frame

 in terms of the components $\vec{E}$ and $\vec{B}$ in the $S$ frame, where both frames are inertial.

 **4 marks**

 (ii) Find the magnetic field of a point charge in uniform motion. **4 marks**

**QUESTION 5**

 5. (a)(i) What is a four-vector and how is it different from a Euclidean vector? What do you

 understand by invariance of the space-time interval? **4 marks**

 (ii) Show that the Lorentz coordinate transformation is an orthogonal transformation.

 **3 ½ marks**

 (b)(i) In matrix notation, write down the components of the momentum and force

 four- vectors. **4 marks**

 (ii) Show that the magnitude of the momentum four-vector is$ im\_{0}c$, where $i$ is $\sqrt{-1}$, $ m\_{0}$ the rest mass and $c$ the speed of light. **3 ½ marks**