PHYS 4330 Theoretical Mechanics

Homework # 2

Submission deadline: 23 January 2024 at 11:59 pm Eastern Time

Submission Instructions: Homework is submitted on Gradescope to Homework 2.

1. A meter stick is at rest in reference frame S_0, which is traveling relative to reference frame S with speed v=0.75c in the positive x-direction of S. *[This is the setup for both parts (a) and (b)].*

(a) The stick lies in the x_0, y_0 plane and makes an angle θ_0=45° with the x_0 axis (as measured in S_0.) What is the length *l* of the meter stick as measured in S, and what is its angle θ with the x-axis?
(b) Now assume that you measure an angle of θ=45° in S. What is θ_0 for this to happen? What is the value of *l*, as measured in S now?

[10 points]

2. A rocket is traveling at speed V=0.95c along the x-axis of frame S. It shoots a bullet whose velocity **v**' (measured in the rocket's rest frame S') is v_y'=0.9c along the y' axis of S'. *[Assume that the x and x' axes are aligned as are the y and y' axes.]*

(a) **Derive** the equation for x and y velocities in the S' reference frame (v_x' and v_y') in in terms of the velocity in the S frame and V.

(b) Calculate the individual velocity components in the S frame and report the bullet's total velocity (magnitude and direction) as measured in S?

[10 points]

3. Cosmic rays create muons in the Earth's upper atmosphere. These muons rain down more-or-less uniformly on the Earth's surface, although some of them decay on the way to the surface, with a half-life of ~1.5 μs (measured in their rest frame). A muon detector is carried in a balloon to an altitude of 2000 m, and in the course of an hour detects 650 muons traveling at 0.99*c* toward the Earth.

(a) What is the muon's half-life as measured by an observer on the surface of the Earth?

(b) If an identical detector remains at sea level, how many muons should it register in one hour?

(c) What would the answer be if you ignore the effects of time dilation?

[10 points]