Problem set #1 (Modern Physics)

03/15/2018 Provided by *Masahito Oh-e*

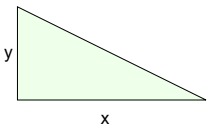
Solve the problems below. Describe the ways of thinking in English: only final solutions are not accepted. Make clear how you reach each solution.

Problem 1.
A spaceship is measured to be 100 m long while it is at rest with respect to an observer. If this spaceship now flies by the observer with a speed of 0.99c, what length will the observer find for the spaceship?

Problem 2.
Two trains are oppositely approaching at the speed of 0.6c, respectively. Suppose an observer is in one of the train, what is the relative speed of the other train with respect to the observer?

Problem 3.
An electron, which has a mass of 9.11 X 10^{-31}kg, moves with a speed of 0.750c. Find its relativistic momentum and compare this with the momentum calculated from the classical expression.

Problem 4.
A spaceship in the form of a triangle flies by an observer at 0.950c. When the ship is measured by an observer at rest with respect to the ship, the distances x and y are found to be 50.0 m and 25.0 m, respectively. What is the shape of the ship as seen by an observer who sees the ship in motion along the direction?



Problem 5.
Muons are unstable elementary particles that have a charge equal to that of an electron and a mass 207 times that of the electron. Muons are naturally produced by the collision of cosmic radiation with atoms at a height of several thousand meters above the surface ofthe Earth. Muons have a lifetime of only 2.2 μs when measured in a reference frame at rest with respect to them. If we take 2.2μs (proper time) as the average lifetime of a muon and assume that its speed is close to the speed of light, we would find that these particles could travel a distance of about 650 m before they decayed. Hence, they could not reach the Earth from the upper atmosphere where they are produced. But we do observe some of the muons reach the earth. Explain why muons can reach the earth.

Problem 6.
There is a twin, A and B. Suppose when they are 20 years old, A makes a round trip to the Centaurus α star that is 4.4 light-years far away from the earth by spacecraft at the speed of v=0.99c. When A returns the earth and see B, how old is each of them?