EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE – 2013/2014

SECOND SEMESTER (PROPER/REPEAT)

(OCTOBER 2016)

PH 205 RELATIVITY

Time: 01 hour
Answer ALL Questions

Q1. State the fundamental postulates of the special theory of relativity and hence deduce the Lorentz transformation equations. Using the Lorentz transformation equations obtain the velocity transformation equations

$$U_x' = \frac{U_x - \beta c}{1 - \frac{U_x \beta}{c}},\ U_y' = \frac{U_y}{\gamma\left[1 - \frac{U_x \beta}{c}\right]} \text{ and } U_z' = \frac{U_z}{\gamma\left[1 - \frac{U_x \beta}{c}\right]}$$

where the symbols have their usual meaning, and $v = \beta c$.

A spaceship moves away from Earth with speed v and fires a shuttle craft in the forward direction at a speed v relative to the spaceship. The pilot of the shuttle craft launches a probe in the forward direction at speed v relative to the shuttle craft. Show;

(i) the speed of the shuttle craft relative to the Earth is;

$$\bar{v} = \frac{2v}{1 + \beta^2}$$

(ii) the speed of the probe relative to the Earth is;

$$u_x = \left(\frac{3 + \beta^2}{1 + 3\beta^2}\right) v$$

Hence, deduce that $u_x \to 3v$, when $\beta \to 0$.

Q2.

Define the terms relativistic energy E and relativistic momentum p particle in terms of its velocity v, rest mass m, and the speed of light c.

Hence, show that Energy-Momentum equation of the particle is given by

$$E^2 - p^2c^2 = m^2 c^4 ,$$

and

$$\beta = \frac{v}{c} = \frac{pc}{E}.$$

Prove that the quantity $E^2 - p^2c^2$ is invariant.

The symbols have their usual meanings.

A photon of energy E travelling in the positive (+) x direction coll elastically with an electron of mass m moving in the opposite direction. A the collision, the photon travels back along the negative (–) x direction the same energy E.

(i) Use the conservation of energy and momentum to demonstrate that initial and final electron momenta are equal and opposite, and magnitude E/c.

(ii) Hence, show that the electron speed is given by

$$\frac{v}{c} = \left[1 + \left(\frac{mc^2}{E}\right)^2\right]^{-\frac{1}{2}}.$$