Introductory Quantum Physics – Phys 202H Midterm, Oct 16th, 2007

Allowed: Formula sheet, (given), calculator

Time allowed: 55 mins. Each part has equal marks. Show your thoughts!.

Advice: Don't cram your answers into too small a space – try to spread out your answers.

Section A: Answer **all** questions

A1. A pion lives 26 ns in its rest frame. How long does an observer in the laboratory in which the particle moves at a speed of 2.7×10^8 m/s say the particle lived?

A2. A Canadian football field is 100 m long and 60 m wide. How long is the field as seen by an observer traveling at 0.6*c* along the long axis of the field?

A3. An astronaut on a spaceship enroute to Mars with a speed of 0.5c relative to the earth observes a meteor approaching head on at a speed of 0.9c relative to the spaceship. What is the speed of the meteor relative to the earth?

A4. A particle moves in such a way that its kinetic energy just equals its rest energy. What is its speed?

Section B: Answer **one** question

B1. A flare is set of at location A at time t = 0. A second flare is set off at location B, 1500 km from A, at $t = 3\times10^{-3}$ s.

a) Find the time interval between the two flares in the reference frame of a spaceship travelling along the AB direction (i.e. in the direction from A to B) at 10^5 km/s.
b) Find the distance between location A and location B according to observers on the spaceship
c) Find the spatial separation between the two flares according to the spaceship observers
d) How fast would the spaceship be moving if the flares were simultaneous in the spaceship frame?

B2. A particle of mass *m* is moving along the *x*-axis with velocity *v* and collides perfectly inelastically with a particle of mass *m*/2 moving along the *x*-axis with velocity –*v*.

a) Draw a 'before' and 'after' diagram showing the collision
b) By using appropriate conservation laws, show that the mass of the final particle, m_1, is

$$m_1 = \frac{m}{2}\sqrt{\frac{9 - v^2/c^2}{1 - v^2/c^2}}$$