Written Examination Special Relativity F8066

Academic Year 2003–2004: 20 September 2004, 2.30-4.30 PM

Please read the following **INSTRUCTIONS**

A. Answer at most TWO questions. You may answer in english or in italian. A pass is obtained for one complete answer, and full marks for two complete answers.

B. You may not use notes or textbooks, but the course notes are available for consultation at the front desk.

1. Argue that the set of all Lorentz boosts is a group (the direction of the x and x' remaining the same). What are the physical meanings of the identity and the inverse of an element in this group? Is this group abelian? Given a pair of consecutive transformations corresponding to velocities v_1 and v_2, what is the velocity corresponding to the composition of the two transformations? Justify all answers.

2. Show that if two inertial frames K and K' have relative velocity of magnitude v, then there exists a third inertial frame K'', relative to which the frames K and K' have opposite velocities of the same magnitude u, and express u in terms of v.
Ans. solve $u = \frac{v-u}{1-uv/c^2}$ for u, solution $u = \frac{c^2(1\pm\sqrt{1-v^2/c^2})}{v}$

3. An observer moves *into* parallel radiation of frequency ν at an angle $\pi/6$ with the radiation, and at a speed $c/2$. What frequency is observed?
Ans. Doppler with $\theta = 5/6$ (moving *into* parallel radiation) gives

$$\frac{\nu_{obs}}{\nu} = \frac{1}{\gamma(1 + \frac{v}{c}\cos\theta)} = 1.52$$

4. If particle 1 has mass m_1 and particle 2 has mass m_2 and the energy of particle 2 is E in a frame of reference in which particle 1 is at rest, what is the energy of particle 1 in a frame of reference in which particle 2 is at rest? Justify your answer.

1. $m_1 m_2/E$

2. $m_2 E/m_1$

3. $m_1 E/m_2$

4. none of these

Ans. Number 3 is correct