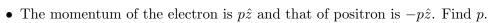
## PH110: Tutorial Sheet 6

- 1. Two events A and B occur in frame S with coordinates  $(x_A = 150 \, m, t_A = 0.3 \, \mu \, s)$  and  $(x_B = 210 \, m, t_B = 0.4 \, \mu \, s)$  respectively. Could these events appear simultaneous to an observer in another frame? If yes, what is the velocity of that frame, relative to S?
- 2. Two spaceships pass each other, travelling in opposite directions. The speed of ship B, measured by a passenger in ship A is 0.96c. This passenger has measured the length of the ship A as 100 mt and determines that the ship B is 30 mt long. What are the lengths of the two ships as measured by a passenger in ship B? Ans: (28m, 107.14m)
- 3. An observer O is at the origin of an inertial frame. He notices a vehicle A to pass by him in +x direction with constant speed. At this instant, the watch of the observer O and the watch of the driver of A show time equal to zero. 50  $\mu$ s after A passed by, O sees another vehicle B pass by him, also in +x direction and again with constant speed. After sometime B catches A and sends a light signal to O, which O receives at 200  $\mu$ s according to his watch. The driver of B notices that, in his frame, the time between passing O and catching A is 90  $\mu$ s Assume that drivers A and B are at the origins of their respective frames. Find
  - (a) the speeds of B and A, in the frame of O.
  - (b) position of A in O's frame when B passes O.
  - (c) the position of O in the frame of A, when B passes O.

Ans: ((81/17)c, (6/19)c, (90/19) km, -5 km)

- 4. Pioneer-11 spacecraft is moving away from earth at a speed of about 12,000 m/s. It communicates with earth by emitting microwaves of frequency  $52.353 \times 10^9$  Hz. What should be the tuned frequency of the antenna on earth so that the signal from Pioneer-11 can be received? Ans: (52. 351 GHz).
- 5. The  $H_{\alpha}$  line, emitted by hydrogen, is a bright red line with wave-length  $656.1 \times 10^{-9}$  m. The  $H_{\alpha}$  lines measured from diametrically opposite ends of sun's equator differ in wave-lengths by  $9 \times 10^{-12}$  m. Assuming that this difference occurs due to the rotation of the sun, find the period of rotation of the sun. The diameter of the sun is  $1.4 \times 10^9$  m. Ans: (25 days).
- 6. A particle has rest mass  $m_0$  has energy  $4m_0c^2$ . What is its momentum, in units of  $m_0c$  What is the energy of this particle, when its momenum is  $2m_0c$ ? Ans:  $(\sqrt{15}m_0c, \sqrt{5}m_0c^2)$
- 7. A particle has rest mass energy 100 MeV. Calculate its total energy if it moves with speed (a) 0.9c, (b) 0.99c and (c) 0.999c.
- 8. A  $\rho$ -meson of rest-mass energy 760 MeV decays into two  $\pi$ -mesons, each of rest-mass energy 150 MeV. Find the speed of one  $\pi$ -meson relative to the other. Ans: (0.997c).
- 9. Let  $m_0$  be the mass of electron and also of its anti-particle positron. Assume that a hypothetical particle X of mass  $4m_0$  is produced in the collision of an electron and positron. Consider the following two situations:



• The electron is at rest and the positron has momentum  $q\hat{z}$ . Find q and the speed with which X is produced.

Ans:  $(\sqrt{3}m_0c, \sqrt{48}m_0c, (\sqrt{3}/2)c)$ 

10. A pion of rest mass energy 140 MeV (MeV is million electron-volts) decays into a muon of rest mass energy 100 MeV and a neutrino of rest mass energy zero. In the rest frame of pion, calculate the momentum of the muon in units of MeV/c. Also calculate its speed. Ans: (24.29 MeV/c, 0.324c).