

Winter Quarter 2014 – Physics 24 Midterm

Problem 1

Two equal charges Q are at rest in frame S . They are at $x = 0$, $y = \pm d$.

- (a) Find the electric field in S at a point P with $x = d$, $y = 0$. Give your answer in terms of field components ie, $E_x = \dots$ and $E_y = \dots$;
- (b) Now consider a frame S' that moves with velocity v in the positive x direction. The origins of frames S and S' coincide at $t = t' = 0$. What is the electric field in S' at the point P at time $t' = 0$.

Problem 2 (you can use $c=1$ if you like)

A particle of mass M decays in its rest frame S into two photons.

- (a) Find the energy and the magnitude of momentum of each photon in S .
- (b) In the frame S' the particle (before decaying) is observed to be moving with momentum P in the positive x' -direction. What is the velocity of the S' frame in the S frame. Make sure to specify the direction, not just the magnitude. Express your answer in terms of P and M . (The direction of the axes in S and S' are the same).
- (c) In the frame S , one of the photons is emitted in the positive y -direction. Let θ' be the angle that the photon makes with the x' -axis in the S' frame. Find this angle, ie, find $\tan \theta'$ or $\sin \theta'$ or $\cos \theta'$. (You need to find only one of these three quantities).

Problem 3

A futuristic train moving in straight line with a uniform speed of $0.8c$ passes a series of communication towers. The spacing of the towers according to an observer on the ground is 3.0 km. A passenger on the train uses an accurate stopwatch to measure how often the train passes a tower.

- (a) What is the time interval the passenger measures between the passing of one tower and the next? Use $c = 3.0 \cdot 10^8$ m/sec.
- (b) What is this time as measured by the observer on the ground?

Problem 4

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 a speed v relative to the shuttle craft.

- (a) Find the velocity of the shuttle craft with respect to the earth.
- (b) Find the velocity of the probe craft with respect to the earth.