Phys 321-E&M II-Final Exam-Dec. 14, 2005

1.(25 pts) A long solenoid with radius *a* and *n* turns per unit length carries a time-dependent current I(t) in the $\hat{\phi}$ direction. Find the electric field (magnitude and direction) at a distance *s* from the *z* axis (both inside and outside the solenoid), in the quasi-static approximation.

2.(25 pts) Write down the (real) electric and magnetic fields for a monochromatic plane wave of amplitude E_0 , frequency ω , and phase angle zero that is traveling in the direction from the origin to the point (1, 2, 3), with polarization parallel to the *xy* plane.

3.(25 pts) Suppose a point charge q is constrained to move along the x axis. The charge has a velocity v and acceleration a. Determine the electric and magnetic fields at points on the axis to the <u>left</u> of the charge (*i.e.*, behind the charge and on the x axis).

4. (25 pts) A certain truck is three times as long as a VW Beetle, when they are at rest. As the truck overtakes the VW, going through a speed trap, a (stationary) policeman observes that they both have the same length. The VW is going at one-third the speed of light; that is, $u_{VW} = c/3$. How fast is the truck going? Leave your answer as a multiple of *c*.

5. (17 pts) Event *A* happens at the point (x = 5, y = 2, z = 1) and at a time *t* given by ct = 1; event *B* occurs at (3, 2, 1) and ct = 4, both in system *S*.

a) Find the invariant interval between A and B.

b) Is the invariant interval timelike, spacelike, or lightlike?

c) Find the velocity of an inertial system relative to S so that the events occur simultaneously or the events are at the same spatial point.

d) Determine the coordinates of event A in the new inertial system, that is, $(\bar{x}, \bar{y}, \bar{z})$ and $c\bar{t}$.

6. (25 pts) A neutral pion of (rest) mass *m* and relativistic momentum $p = \frac{1}{3}mc$ decays into two photons. One of the photons is emitted in the same direction as the original pion, and the other in the opposite direction. Find the (relativistic) energy of each photon.

RECALL: Lorentz transformation:
$$\overline{x} = \gamma (x - vt) \quad \overline{y} = y \quad \overline{z} = z$$
$$\overline{t} = \gamma (t - \frac{v}{c^2}x) \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\vec{p} = \gamma_u m \vec{u}$$
 $E = \gamma_u m c^2$ $E^2 = p^2 c^2 + m^2 c^4$ $\frac{u}{c} = \frac{pc}{E}$ $p^\mu = \langle E/c, \vec{p} \rangle$