PHYS 942 Final Exam

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PHYS 942
December 14, 2018, 10:30 - 12:30 am
251 DeMeritt

Name, please write clearly: _____

Note: Open book (Zingwall, Jackson). 250 points max, 100 are a perfect score! Please write clearly. **Show all your steps!**

1. (*50 points*) Consider a rotating electric dipole $\mathbf{p}$ such that the dipole lies in the x-y plane and rotates about the z-axis with angular velocity ω. Calculate $dP/d\Omega$ as a function of distance r and the angle θ between the observer and the z-axis. Hint: You can construct a rotating dipole from two oscillating linear dipoles, which is most conveniently expressed as a complex dipole.

2. (*50 points*) A particle of mass M and 4-momentum P decays into two particles of mass m_1 and m_2. Use the invariance of scalar products of 4-vectors to determine the the *total* energy and the *kinetic* energy of the resulting particles in the rest frame of the decaying particle.

3. (*50 points*) A light beam of intensity (power/area) I_0 and frequency ω_0 directed along the positive x-axis is reflected normally by a perfect mirror moving along the positive x-axis with velocity v. What is the frequency ω and the intensity I of the reflected light in terms of ω_0 and I_0?

4. (*50 points*) Search light effect: Consider a light bulb that moves past you at relativistic speed v. In the bulb's frame, the light rays emanate isotropically from the bulb. Show that for a light ray that emanates at an angle θ' relative to the x-axis from the bulb in the moving frame, in the stationary frame that ray lies at an angle θ to the x-axis, with θ given by:
$$\cos\theta = \frac{\beta + \cos\theta'}{1 + \beta\cos\theta'}.$$
(hint: L.T. of the (ω/c,$\mathbf{k}$) 4-vector.) Draw a sketch of the light rays as seen from the stationary observer. This is called the "relativistic searchlight effect."

5. (*50 points*) Consider an infinite, circular, uniform ion beam of radius R at reativistic speed v. Calculate the force *in the lab frame* on a single beam ion located at disrance r ($r < R$) from the centerline of the beam.