1. Use the Lorentz transformation to show that the electric field caused by a point charge moving with constant velocity **v** is

$$E(\mathbf{R}) = \frac{e}{4\pi\epsilon_0}\frac{\mathbf{R}}{R^3}\frac{1-\frac{v^2}{c^2}}{(1-\frac{v^2}{c^2}\sin^2\theta)^{3/2}},$$

where **R** is the displacement from the charge at the given moment and θ is the angle between **v** and **R**. Draw a conclusion that the electric field caused by charged particle moving with large velocity can be seen as a short pulse at angle $\theta = \pi/2$ ($\Delta\theta \propto \sqrt{1-v^2/c^2}$).

2. Use Maxwell's equations in 3-vector form and the generalization of equation

$$\frac{dE_{kin}}{dt} = e\mathbf{v}\cdot\mathbf{E}$$

to derive the law for conservation of energy

$$\frac{d}{dt}\Big[\sum E_{kin} + \int dV(\frac{\epsilon_0}{2}E^2 + \frac{1}{2\mu_0}B^2)\Big] = -\oint d\mathbf{a}\cdot\mathbf{S}.$$

S is the Poynting vector defined as

$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E}\times\mathbf{B}.$$