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Phys332/Final Exam
Saturday 23/1/2021

1. (10 %) A square loop of wire with sides length a, lies in the first quadrant of the xy-plane, with one corner at the origin. In this region, there is a non-uniform time-dependent magnetic field $\vec{B}(x,y,t) = 16x^3y^3t^2\hat{z}$. Find the emf induced in the loop.

2. (15%) Consider an electromagnetic plane wave that is linearly polarized in the x-direction (i.e. $\vec{E} = E_0 e^{i(kz-\omega t)}\hat{x}$). Using Maxwell's equations, show that $(i)\ \vec{E} \perp \vec{B}$ $(ii)\ E_0 = cB_0$.

3. (15%) Consider a sphere with a total charge Q uniformly spread on its surface, with a radius $R(t)$ which pulsates: $R(t) = R_0 + R_1\cos(\omega t)$, where $0 < R_1 < R_0$, so $R(t)$ is always positive. Show that this system does not radiate, even though the charges are accelerating.

4. (16%) If in an inertial system ($\bar{S}$) that is moving with a speed v to the right relative to another inertial system S, show that for an electromagnetic wave that satisfies $\vec{E}\cdot\vec{B} = 0$ and $E^2 = cB^2$ in S, satisfies $\bar{\vec{E}}\cdot\bar{\vec{B}} = 0$ and $\bar{E}^2 = c\bar{B}^2$ in $\bar{S}$.

5. (10%) If the electric and magnetic fields are perpendicular at some point (x,y,z) in frame of reference S. Find the velocity v of $\bar{S}$ relative to S in which $\bar{B} = 0$ at $(\bar{x},\bar{y},\bar{z})$.

6. (10%) A frame $\bar{S}$ moves with a constant velocity $\vec{v}$ along x relative to S. If a rod in $\bar{S}$ makes the angle $\bar{\theta}$ with the direction of motion. What angle does the rod makes in S?

7. (24%) Consider two identical charges separated by a vertical distance d and moving parallel to each other with a velocity $\vec{v} = v_0\hat{x}$ with respect to the lab frame of reference (S). Find the force between the two charges in S.

   Hint: This can be done by first finding the force between the two particles in a frame of reference ($\bar{S}$) that move with a velocity $\vec{v}$ with respect to S and in which the two charges at rest, and subsequently transforming the force appropriately to find in S.