Problem Set 1
Physics 483 / Fall 2002
Professor Klaus Schulten

Problem 1: We need your e-mail address

Send an e-mail with your full name to Deyu Lu ⟨ deyulu@ks.uiuc.edu⟩.

Problem 2: Lorentz Group

(a) Prove the commutation properties given in Eq. (10.49) of the class notes for : $k = 2$, $\ell = 3$.

(b) Repeat (a) for Eq. (10.133).

Problem 3: Lorentz Group

(a) Show that Eq. (10.112) is equivalent to the inhomogenous Maxwell equations.

(b) Show that Eq. (10.113) is equivalent to the homogenous Maxwell equations.

Problem 4: Lorentz Transformations

(a) Consider a cube, orinted with its sides parallel to the x^1, x^2, x^3–axes, moving along the x_1-axis with velocities (in units of c) $v = 0, \frac{1}{10}, \frac{1}{2}, \frac{9}{10}$. Plot the cube as it appears to an observer in a frame at rest.

(b) Using the transformation behaviour of the momentum 4-vector p^μ prove the addition theorem of velocities. Restrict the derivation to motion along the z-axis.

(c) Verify Eq. (10.107).

(d) A thin wire along the x_3-axis carries a charge density $\frac{q}{\ell}\,\delta(x_1)\,\delta(x_2)$. Determine the electrical and magnetic field in the rest frame when the wire moves along the x_3-axis with velocities (in units of c) $v = 0, \frac{1}{10}, \frac{1}{2}, \frac{9}{10}$.

(e) A pion is described in the rest frame by the wave function $\psi_o(\vec{p}, \lambda | x^\mu)$ with $\vec{p} = (0, 0, p)^T$ (i.e., momentum along the z-axis). Determine the wave function in a frame moving along the z-axis with velocity $\tilde{v}$, applying the corresponding Lorentz-transformation $\mathcal{L}(\tilde{w}^3)$. Compare the result with (b).

The problem set needs to be handed in by Thursday, September 12, 2002 into the mail box of Deyu Lu in Loomis.