Problem Set 4

Physics 322
Electrodynamics II

Due on Friday, February 16th, 2024

Problem 1

Griffiths 10.15 — potentials for a charge moving in a circle.

Problem 2

For the configuration from the previous problem, find the electric field along the $\hat{\mathbf{z}}$ axis using (10.72).

Problem 3

Griffiths 10.17 — causal connectivity for hyperbolic motion.

Problem 4

Griffiths 10.20 — electric and magnetic fields in one dimension.

Problem 5

Griffiths 10.22 — using the point charge fields to compute the fields of an infinite line of charge moving with constant velocity.

Problem 6

A point particle with charge q_1 is at rest at the origin. Another point particle, with charge q_2 moves up the z-axis with $\mathbf{w}(t) = vt\hat{\mathbf{z}}$. What is the force of q_1 on q_2 at time t? What is the force of q_2 on q_1 at time t? Thoughts?

Presentation Problems

Here are two presentation problems (see syllabus for a description of the writeup/in-class presentation). Everyone should solve these problems – if you choose to present one, either in-class or in written form, it will be due on Friday, February 16th (I'll ask for volunteers for in-class presentations on Monday, February 12th).

Problem 1*

At time $t = 0$, a charge q is observed at rest at location d along the $\hat{\mathbf{x}}$ axis, and another charge $-q$ is observed at rest at $-d$. Using those initial conditions, and letting $x_\ell(t)$ refer to the position of the particle at rest at $-d$ at $t = 0$ (so that $x_\ell(0) = -d$, $\dot{x}_\ell(0) = 0$), $x_r(t)$ refer to the position of the particle at rest at d at $t = 0$ ($x_r(0) = d$, $\dot{x}_r(0) = 0$), write the equation of motion (assume the particles have identical mass m) and initial conditions governing the two particles as you would find it in Physics 102, or similar first year electricity and magnetism course. Indicate how you might use these equations to find the time T that it takes for $x_r(T) = d/2$, i.e. to halve the initial distance between the two particles.

Write the equation of motion and initial conditions governing the two particles as you would find it in this class. Indicate some (!) of the difficulties in solving these equations to find the time T at which $x_r(T) = d/2\ldots$

Problem 2*

In this problem, we'll work out the behavior of power $P = \frac{dU}{dt}$ (using U for energy here) under a Lorentz boost. Consider a box of side length $\bar{\ell}$ sitting in $\bar{L}$. A particle of mass m starts off in the middle of the box and moves with speed $\bar{v}$ (relative to $\bar{L}$) to the right. Over a time interval $\Delta\bar{t}$, it moves a distance $\Delta\bar{x} = \bar{\ell}$, so that $\Delta\bar{t} = \bar{\ell}/\bar{v}$, and ends up outside the box. How much energy, $\Delta\bar{U}$, leaves the box over the time interval $\Delta\bar{t}$? What is the power measured in $\bar{L}$: $\bar{P} = \Delta\bar{U}/\Delta\bar{t} =$? Now use the "usual setup" in which $\bar{L}$ is moving to the right with speed v through L (as shown in Figure 1) — what is the loss of energy in the box, ΔU, and over what time Δt does it occur in L? Write the power loss in L, $P = \frac{\Delta E}{\Delta t}$, and relate it to $\bar{P}$.

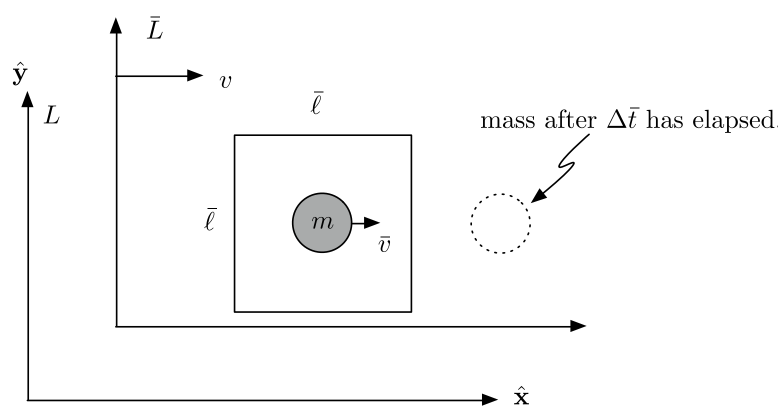

Figure 1: Figure for Problem 2*.