

## E&M 2: Sample Questions on Chapters 12

**Question 1:** Consider two point charges at rest on the y-axis,  $+q$  at  $y = +d/2$ , and  $+q$  at  $y = -d/2$ .

1a. Calculate the total electromagnetic force between the two charges at rest.

1b. Now, imagine that the two charges are in motion, each with a velocity  $v$  in the  $+x$  direction. Calculate the electromagnetic force (in the original rest frame) between the two charges in motion by using the Lorentz transformations to find the fields of the charges in motion, and computing the resulting (ordinary) force.

1c. Calculate the electromagnetic force between the two charges in motion (in the original rest frame) by using the Lorentz transformation to find the Minkowski force between the charges in motion, and then finding the ordinary force from the result.

**Question 2:** Consider an extended sheet of charge in the x-y plane with charge density  $\sigma$ . The electric field above the sheet is  $E_z = \sigma/(2\epsilon_0)$ . Now, imagine that this sheet of charge moves in the  $+x$  direction with velocity  $v$ .

2a. Find the electric and magnetic fields above the moving sheet of charge, and construct the field tensor.

2b. Find the four components of the Minkowski force on a point charge moving with velocity  $v_p$  in the  $+z$  direction. Interpret the results in terms of energy and force.

**Question 3:** The four-vector potential of a point charge at rest is  $(k/(rc), 0, 0, 0)$ , with  $k$  an appropriate constant,  $c$  the speed of light, and  $r$  the radial distance from the origin. Use this four-vector potential to construct the field tensor explicitly as a function of  $x, y, z$ .