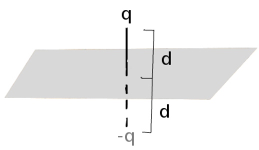
The imperfect electric mirror

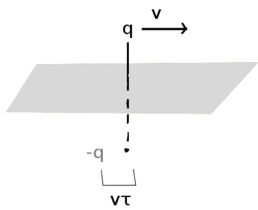
CPL practice problem for the 2nd challenge - Images

As you may have learned in an E&M class or heard in our meeting, surfaces that are perfect conductors do not tolerate electric fields parallel to them, so the charges in the conductor redistribute and cancel out the parallel component of the electric field. For a charge q at a distance d above a conducting plane, these charges in the conductor produce the same field you'd get by putting an *image charge* on the opposite side of the plane. (Note that the fields are only the same above the plane.)

The same image is produced if the plane has a finite resistivity, assuming that charge q is stationary. But if charge q is moving, then the charges in the plane don't completely cancel the parallel component of the field. Consider charge q moving with velocity v parallel to a thin metallic film. Assume it is held at constant distance d from the surface. Because of the finite resistivity in the film, charge can't instantly move to screen the outside charge, and the image charge lags from the moving charge by an amount $\delta = v\tau$. The current in the film dissipates energy; this energy is drawn from the moving charge q. This is because the image lags behind the moving charge and has a small horizontal pull on it.



(a) Fixed charge



(b) Moving charge

If the metallic film has a two-dimensional resistivity ρ, can you find an expression, that is correct up to an numerical constant, for the dissipative force coefficient η that the outside charge experiences? ($F = -\eta v$). No need for calculations–**use dimensional analysis**.

Comment: 2D resisitiviy is such that the resistance through a strip w wide and L long is $R = \rho L/w$.