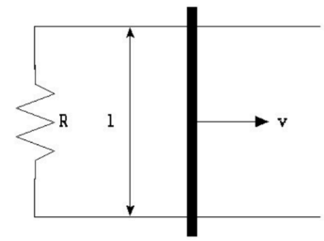
Homework #1 (10 points) - Show all work on the following problems:

Problem 1 (2 points): Consider two concentric metal spherical shells, of radius a and b ($a < b$), separated by conductive material with conductivity σ.

1a (1 point). If the two shells are maintained at a potential difference ΔV, what current I flows from one to the other?

1b (1 point). What is the effective resistance R of this configuration?

Problem 2 (3 points): Consider a metal bar of mass m, sliding frictionlessly on two parallel conducting rails a distance l apart, with a resistor R connected across the rails. A uniform magnetic field B points into the page and fills the entire region.



2a (1 point): If the bar moves to the right with speed v, what is the current (magnitude and direction) in the resistor?

2b (1 point): What is the magnetic force (magnitude and direction) on the bar?

2c (1 point): If the bar starts out with speed v_0 at $t = 0$, what is its speed at a later time t?

Problem 3 (1 point): To compute the magnetic flux $\Phi_B = \int \vec{B} \cdot \overrightarrow{da}$, which is differentiated to determine the motional EMF around a loop, we do not need to specify the surface over which the flux should be calculated, only the loop that forms the boundary of that surface. Why doesn't the specific surface matter?

Problem 4 (2 points): Consider a square loop of wire with sides of length a, lying in the x-y plane, extending from the origin to the point $(x,y) = (a,a)$. If the magnetic field is $\vec{B}(x, y, t) = k y^3 t^2 \hat{z}$ (with k a constant), what is the EMF induced around the loop?

Problem 5 (2 points): Consider a long solenoid of radius a, with n turns per length, with a current that increases linearly with time (i.e. $I_s(t) = kt$, with k a constant). If a loop of wire with resistance R is placed around the solenoid, what current I_r flows in the loop? Is the loop current in the same direction or the opposite direction as the solenoid current?