**Homework #3 (10 points) - Show all work on the following problems:**
*(Grading rubric: Solid attempt = 50% credit, Correct approach but errors = 75% credit, Correct original solution = 100% credit, Copy of online solutions = 0% credit)*

**Problem 1 (20 points):** Given a parallel plate capacitor immersed in sea water with permittivity $\varepsilon = 81\varepsilon_0$, permeability $\mu=\mu_0$, and resistivity $\rho = 0.23\ \Omega\ m$, with a sinusoidally varying voltage $V(t) = V_0 \cos(2\pi\nu t)$ with amplitude $V_0$ and frequency $\nu = 4 \times 10^8$ Hz between the plates, what is the ratio between the amplitudes of the conduction current and the displacement current $\overrightarrow{J_d} = \frac{\partial \vec{D}}{\partial t}$?

**Problem 2 (30 points):** Calculate the total electromagnetic energy per unit time transported down a coaxial cable consisting of an inner cylinder with radius *a* and an outer cylinder with radius *b* (*as in Example 7.13 in Griffiths*). Assume the two conductors are held at a potential difference *V*, with current *I* flowing along the surface of the inner cylinder and back along the surface of the outer cylinder.

**Problem 3 (30 points):** Find the electromagnetic force between two equal point charges *q* separated by a distance *2a*, by integrating Maxwell's stress tensor over the plane equidistant between the two charges.

**Problem 4 (20 points):** A charged parallel-plate capacitor (two plates with area *A*, separated by distance *d*, carrying charge *+Q* and *-Q*) has its positively charged plate in the x-y plane (*z=0*), and its negatively charged plate at *z = d*. There is thus a uniform electric field *E* pointing in the +z direction between the plates. In addition, there is a uniform external magnetic field *B* pointing in the +x direction.

**4a (10 points):** Find the magnitude and direction of the electromagnetic momentum in the space between the plates, in terms of *E, B, A*, and *d*.

**4b (10 points):** Now assume that a wire with resistance R is connected between the plates, along the z-axis, so that the capacitor slowly discharges. The current through the wire will experience a magnetic Lorentz force. What is the magnitude and direction of the total impulse (Impulse = $\int \vec{F}\, dt$) delivered to the system by that force during the discharge, in terms of *E, B, A*, and *d*?