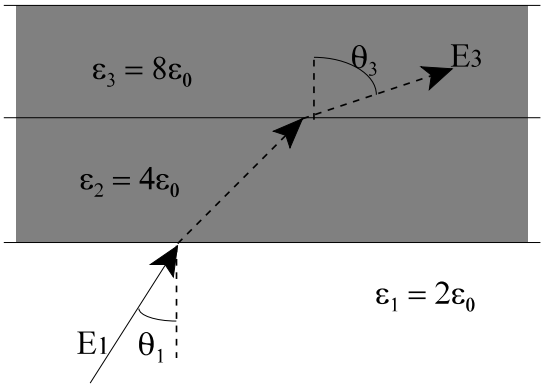
Electromagnetic Theory I
Fall 2002 Exam II

Name_____

Calculator and 3"x5" card of notes permitted.

$dl := d\rho \cdot a_\rho + \rho \cdot d\phi \cdot a_\phi + dz \cdot a_z$ $dl := dr \cdot a_r + r \cdot d\theta \cdot a_\theta + r \cdot \sin(\theta) \cdot d\phi \cdot a_\phi$

1. (8 pts) Optical fiber is often made with "cladding" on the outside: multiple layers of materials with different permittivities to "bend" fringing light rays back toward the fiber center. Something of how this works can be illustrated with static electric fields: given a central dielectric and two cladding layers with permittivities as shown, if the angle of incidence $_1$ of E_1 is 30 degrees, what is the angle $_3$ from the normal made by E_3?



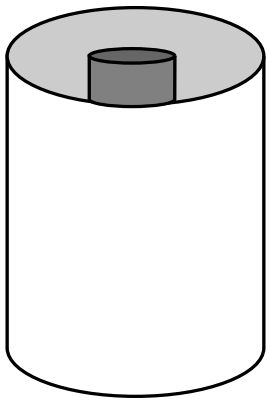
2. (10 pts) A careless technician has left a blob of solder on a printed circuit board. If the blob is considered a hemisphere of radius 1.5 mm on a ground plane, what is the parasitic capacitance it contributes to the circuit? (Hint: assume V = 0 at r = infinity.)

3. (4 pts) A) If a 50-m Olympic-sized swimming pool (water, $_R = 80$, $= 50$ mS/m) is struck by lightning, how long will it take the deposited charge to dissipate?

3 B) If a small backyard pool is struck by the same size lightning bolt, how long will it take the charge to dissipate?

4. (4 pts) If a Hall-effect probe oriented for maximum signal in Kansas reads 2V, and the same probe taken to Greenland reads 2.4 V, what is the ratio of the geomagnetic flux density in Greenland to that in Kansas?

5. (10 pts) A coaxial cable carries 5 mA total on the inner conductor and -5mA on the outer. The inner conductor is solid with radius 1mm and the current may be assumed uniform throughout. The outer conductor is located at radius 2 mm and may be considered infinitely thin. What is the magnetic field intensity everywhere, as a function of position?



6. (4 pts) A serious problem with the large magnets used in MRI is the fringing magnetic field, which can interfere with instrumentation and even make it dangerous to work around the magnet in some cases. Postulate and justify a method or methods for reducing fringing magnetic fields around an MRI solenoid, without reducing interior field intensity.

7. (10 pts) A single-phase power line crosses a damp pasture (looks like a conducting ground plane) at a height of 10m above ground. If we assume it carries a charge 6uC/m, what is the electric field 1m above ground, at the height of a cow's nose, directly under the power line? (No snide comments about computer-generated drawings!)