Homework Assignment #3

due Friday Sept 20

Instructions

Work together but write your own solutions.
The solutions should be complete but concise, and LEGIBLE.
Do not hand in scratch paper.
To aid in grading, for each problem draw a box around your final answers using red pencil.

3-1. Two identical air capacitors (area A, separation d) are connected in series and the combination is maintained at constant potential difference = 50 volts. Now a dielectric sheet (with thickness = 0.1 d and $\epsilon / \epsilon_0 = 10$) is inserted into the air gap of capacitor #1. Calculate the voltage across this capacitor.

3-2. Consider a parallel plate capacitor (dimensions L, w, d) filled with a dielectric slab (dimension L, w, d). Now pull the slab out in direction of L, by a distance x. (Draw a picture.) Now charge the capacitor to charge Q and voltage V_0.
(a) Calculate the force on the slab, by Eq. (4.95).
(b) Calculate the force on the slab, by Eq. (4.102).
(c) Supply a sketch of the system that ***explains*** the direction of the the force.

3-3. Consider a permanent magnet in the shape of a cylinder (length L, radius R). It is uniformly magnetized with $\mathbf{M} = M_0 \hat{\boldsymbol{e}}_z$, parallel to the axis of the cylinder.
(A) Determine $\boldsymbol{J_M}$ and $\boldsymbol{K_M}$.
(B) Compare the results of (A) to a solenoid.

3-4. (A) Determine the magnetization current densities for a uniformly magnetized sphere with $\mathbf{M} = M_0 \hat{\boldsymbol{e}}_z$. The magnetic induction **B** is uniform inside such a sphere.
(B) Design a current winding that will produce a uniform magnetic field in a spherical volume. Draw an accurate picture of the design.

3-5. In one paragraph, describe and explain the historical importance of the "Terrella".

3-6. Jackson Problem 5.19 = a magnetized cylinder. Use a computer to make the plots in part (B).

3-7. (A) Determine $\int_0^{\pi/2} \frac{d\phi}{\sqrt{1 - m \sin^2 \phi}}$. (B) Determine $\int_0^{\pi/2} d\phi \sqrt{1 - m \sin^2 \phi}$.
(C) Determine $\int_0^{2\pi} \frac{\cos\phi \, d\phi}{\sqrt{1 - m \cos\phi}}$. If you use Mathematica, hand in the program.
If you don't use Mathematica, give a reference.