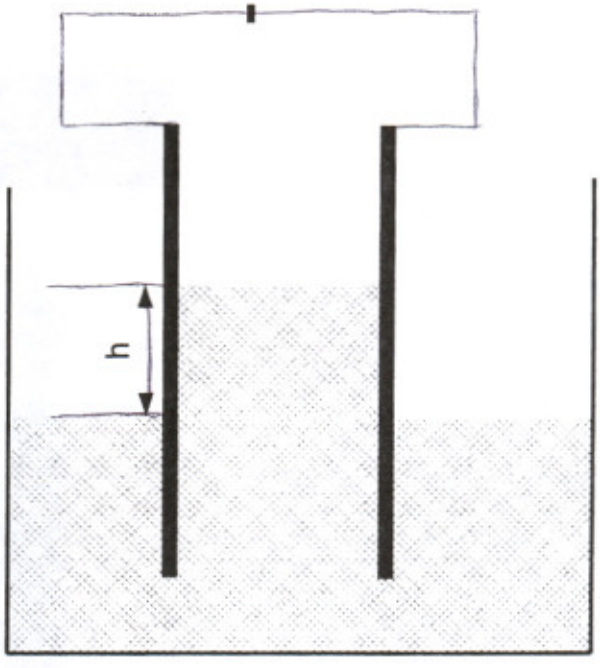
**Candidacy Examination**
**Electricity and Magnetism**
**Fall, 2005**

**Problem 1:** A plane parallel capacitor is placed in a beaker containing an incompressible fluid of permittivity $\varepsilon$ and density $\rho$, so that its plates are vertical. Find the height $h$ to which the fluid will rise in the capacitor, above the level outside. The distance between the plates is $d$ and the potential difference is $V$. Disregard any fringing field effects. (25)




**Problem 2:** A particle of charge $q$ is initially at a large distance from a hollow conducting spherical shell of radius $R$ and thickness $t$ with a very tiny hole. The charge is now moved slowly to the center of the shell through the hole. Calculate the difference in the electrostatic energy of the system. Make sure to include all regions (i.e., inner spherical volume, the shell, and the outside) in your calculations. (25)

**Problem 3:** Two electrons in a CRT are moving at the same but a high but non-relativistic velocity **v**, side by side. The distance between them, measured at right angles to their velocity, is $r$. Calculate the force acting on one of them due to the magnetic field produced by the motion of the other, in the laboratory frame. (25)

**Problem 4:** A conducting rod of length $R$ is placed horizontally in a magnetic field $\boldsymbol{B} = B_o \boldsymbol{k}$ where, $B_o$ is a constant and $\boldsymbol{k}$ is a unit vector in the vertical direction. One end of the rod is at the origin. The rod is now rotated about a vertical axis passing through the origin at an angular frequency $\omega$. What is the potential difference between the two ends of the rod? (25)