Physics 503 **Homework Set 11** **Fall 2016**

Zangwill 9.16 Space-Charge-Limited Current in Matter Consider the vacuum diode problem treated in the text with the space between the plates filled with a poor conductor with dielectric permittivity . For matter of this kind, $v = \tilde{\mu}E$, where the mobility $\tilde{\mu}$ is the constant of proportionality between the drift velocity of the electrons and the electric field in the matter. Find the replacement for the Child-Langmuir law for the dependence of the maximum current density on the material constants, the plate separation L, and the plate potential difference V.

Zangwill 9.23 The Resistance of a Shell A spherical shell with radius a has conductivity?in the angular range $\alpha_1 < \theta < \pi - \alpha_2$. Otherwise, the shell is perfectly conducting and a potential difference V is maintained between $\theta = 0$ and $\theta = \pi$.

(a) Solve Laplace's equation to find the potential, surface current density, and resistance of the shell between $\theta = 0$ and $\theta = \pi$.

(b) Divide the shell into many thin rings. Find the resistance of each and combine them to find the resistance and confirm the answer derived in part (a).

Hint: The substitution $y = \ln[\tan(\theta/2)]$ will be useful.

Zangwill 10.5 A Step off the Symmetry Axis A circular loop with radius R and current I lies in the $x - y$ plane centered on the z-axis. The magnetic field on the symmetry axis is

$$\mathbf{B}(z) = \frac{1}{2}\mu_0 I \frac{R^2}{(R^2 + z^2)^{3/2}}\hat{\mathbf{z}}$$

In cylindrical coordinates, $B_\rho(\rho, z) = f(z)\rho$ when $\rho \ll R$. Use only the Maxwell equations to find $f(z)$ and then $B_z(\rho, z)$ when $\rho \ll R$.