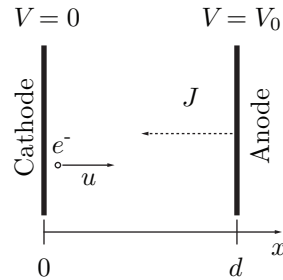# J08E.3 - Parallel Plate Diode

Problem

Consider an ideal parallel plate diode in a vacuum tube. A constant potential difference, $V_0 > 0$, is maintained between the cathode and the anode which are separated by a distance d. Electrons are assumed to be released from the cathode at zero potential with negligible velocity, but are accelerated to the anode. The region between the plates is a vacuum except for the electrons that are emitted into it, leading to a finite space charge density, $\rho(x)$, where x is the distance away form the cathode (see figure). Under steady state conditions, ρ is independent of time, and the continuity equation implies that the current density $J = \rho u$ is independent of x.

a)   Use Poisson's equation to find the potential $V(x)$ as a function of x.

b)   Find an explicit expression for the current density J in terms of V_0 (the Child-Langmuir law).