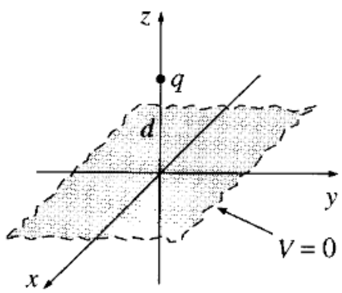
Short Problem 1: (10 points)

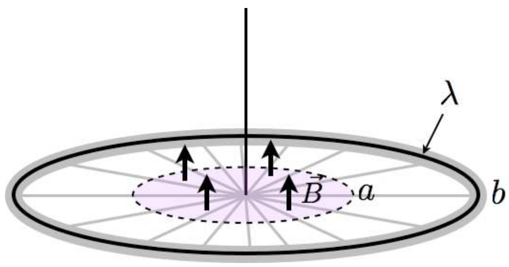
A charge ***+q*** is brought to the position as shown in the figure. The xy plane is a grounded conductor.

(a) Find the electric potential in the space above the xy plane;
(b) Find the force on the charge ***+q***;
(c) Find the surface-charge density induced on the plane;
(d) Find the work needed to remove the charge ***+q*** to infinity.



Short Problem 2: (10 points)

The rim of a wheel of radius b is charged with a linear charge density λ. The wheel is suspended horizontally and is free to rotate. The spokes are made of some non-conduting material. In the central region out to a radius a<b is a uniform magnetic feld B pointing up: see Figure. Explain qualitatively what happens to the wheel when somebody turns the B-field off, and compute the resulting angular momentum given to the wheel.



Long Problem 1:

The electric potential of a given setup is written as

$V(\boldsymbol{r}) = Ae^{-\lambda r}/\boldsymbol{r}$

where A and λ are constants.

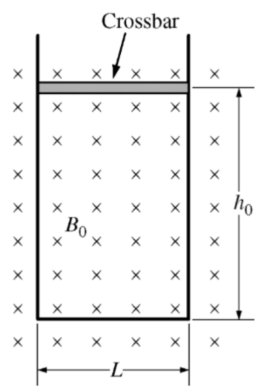
a) Find the Electric Field ($\boldsymbol{E}(\boldsymbol{r})$) for this setup.

b) Find the total charge (**Q**) corresponding to this potential.

c) Calculate the force a doubly charged ion (Z^{++}) would experience in this potential.

Long Problem 2: (20 points)

A closed loop is made of a U-shaped metal wire of negligible resistance and a movable metal crossbar of resistance ***R***. The crossbar has mass **m** and length **L**. It is initially located a distance h_0 from the other end of the loop. The loop is placed vertically in a uniform horizontal magnetic field of magnitude $\mathbf{B_0}$ in the direction shown in the figure. The crossbar is released from rest and slides with negligible friction down the U-shaped wire without losing electrical contact. Express all algebraic answers to the questions below in terms of $\mathbf{B_0}$, **L**, **m**, $\mathbf{h_0}$, ***R***, and fundamental constants, as appropriate.



a) Determine the magnitude of the magnetic flux through the loop when the crossbar is in the position shown.

(b) On the figure below, indicate the direction of the current in the crossbar as it falls.

Justify your answer.

(c) Calculate the magnitude of the current in the crossbar and express it as a function of the crossbar's speed ***u*** when it falls.

(d) Derive, but do NOT solve, the differential equation that could be used to determine the speed ***u*** of the crossbar as a function of time t.

(e) Determine the terminal speed u_T of the crossbar.