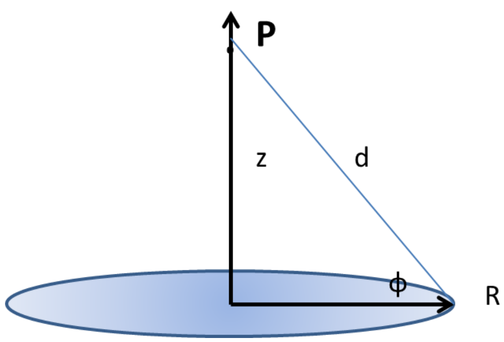
Self-Test: Electric Field Determination and Flux Calculations

B1

A charged disk has a surface charge density function of $\sigma(r) = br^6$ C/m^2, where b is a constant.

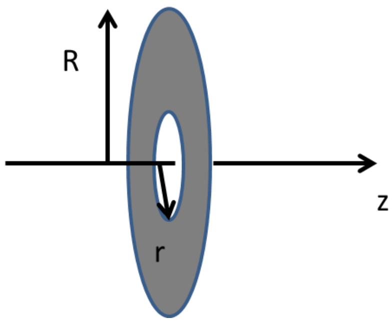
Derive the equation for the electric field at a point P, z above the disk on the axis, assuming the disk has radius R. You can also assume that z >> R



Hint: do two integrations, one varying with angle around the vertical axis, and the other varying with radius.

B2

An electron accelerating plate in an electron microscope is a conducting disk of radius R, with a hole of radius r in it along the axis.



The electric field along the axis of a charged disk of radius R is given by

$$E(z) = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{z}{\sqrt{z^2 + R^2}}\right]$$

(a) Show that the electric field along the z axis is:

$$E(z) = \frac{\sigma z}{2\varepsilon_0}\left[\frac{1}{\sqrt{z^2 + r^2}} - \frac{1}{\sqrt{z^2 + R^2}}\right]$$

(b) For cases where z << r, show that this becomes

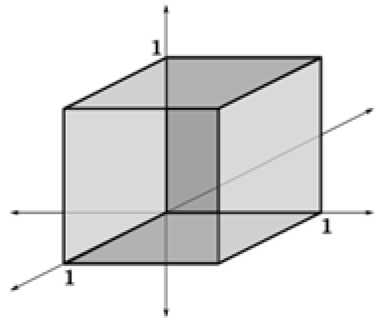
$$E(z) = \frac{\sigma z}{2\varepsilon_0}\left[\frac{1}{r} - \frac{1}{R}\right]$$

(c) For a disk with radius 1.20 cm and hole radius 1.00 mm, calculate the Electric field at a distance 7.00 mm from the disk. Assume that the total charge on the plate is +1.4×10^{-6} C.

B3

The electric field is given by the equation $\vec{E} = (x^2 + 1)\boldsymbol{i} + 9.0y\boldsymbol{j} + z^2\boldsymbol{k}\ V/m$

Now consider the unit cube with the origin at (0,0,0), each side 1.0 m long, and each face with area 1.0 m^2



a) Calculate the net flux of electric field E through each face of the cube (12 marks)
b) Calculate the net flux passing through the cube (4 marks)
c) Use Gauss' Law to determine the charge enclosed in the cube (2 marks)
d) If the unit cube was made up of a dielectric material with κ = 80.4 (water), what would the charge enclosed by, assuming the net flux was the same? (2 marks)