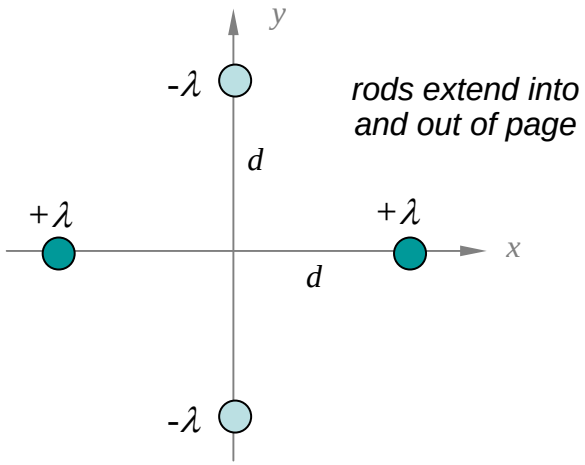
Discussion Question 2D
P212, Week 2
An Electrostatic Quadrupole

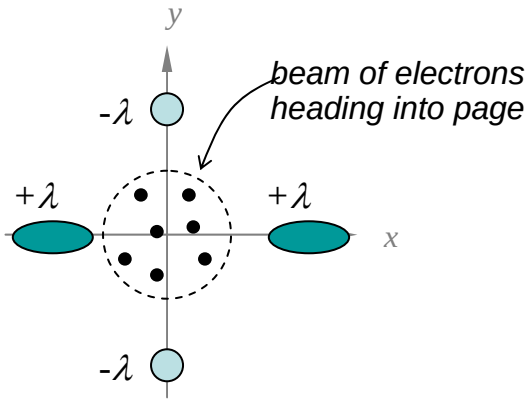
The figure to the right shows a head-on view of four long, parallel charged rails (they extend both into and out of the page). The side rails carry a positive charge per unit length $+\lambda$. The top and bottom rails have the same charge density, but with opposite sign (i.e. they are negatively charged). This arrangement forms an *electrostatic quadrupole*. In the questions below, you will discover why it is useful in devices which contain beams of moving charged particles. *We will not perform <u>any</u> calculations in this question* … all you need is your physical intuition.



(a) Sketch the **electric field lines** in the interior region of the quadrupole.

(b) Given your sketch, where is the electric field the **strongest**? Where is it the **weakest**?

(c) Now imagine that a **beam of moving electrons** enters the quadrupole, with velocity parallel to the charged rods. When the beam enters the device, its cross-sectional profile is circular. What will the beam look like when it *exits* the quadrupole on the other side? (Assume that the force exerted on the electrons is not *too* large.)



(d) The cathode ray tube (CRT) in a TV monitor contains a beam of electrons directed towards a fluorescent screen. The screen lights up where the beam hits it. If you were an electrical engineer designing such a CRT, why might you find it useful to pass the electron beam through a quadrupole before it hits the screen? (A little hint: quadrupoles are usually used in *pairs* … can you figure out why?)