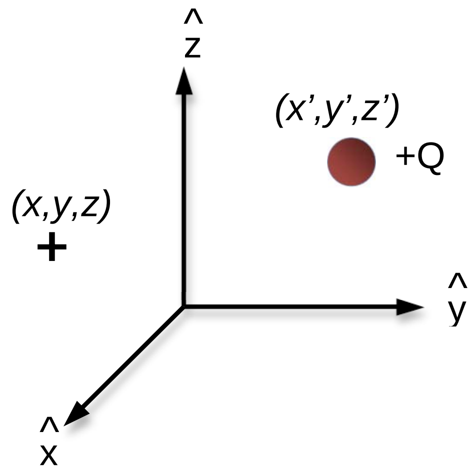
Part 1 – Script-r

There is a charge +Q at point (x’,y’,z’).

We’re concerned with the field at point (x,y,z).

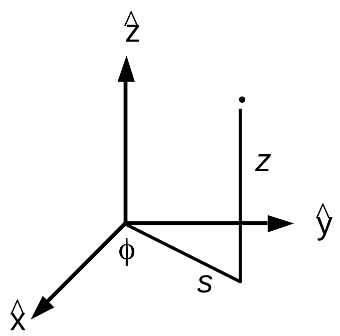
i. Draw on the graph: $\vec{r}$, $\vec{r}\,'$, and $\vec{\mathfrak{R}}$ (where $\vec{\mathfrak{R}}$ is Griffiths’ “script r”).



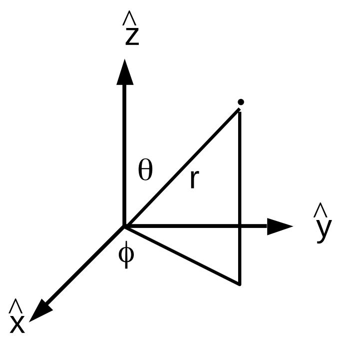
ii. Express $\vec{\mathfrak{R}}$ in terms of $\vec{r}$ and $\vec{r}\,'$.

iii. Now express the Cartesian (R_x, R_y, and R_z) components of $\vec{\mathfrak{R}}$ in terms of the Cartesian components of $\vec{r}$ and $\vec{r}\,'$.

iv. Express the Cartesian *components* of $\vec{\mathfrak{R}}$ = $[R_x , R_y, R_z]$ using <u>cylindrical</u> variables. (Don't try to write $\vec{\mathfrak{R}}$ in a cylindrical coordinate basis. Write each of the *Cartesian* components of $\vec{\mathfrak{R}}$ using appropriate cylindrical variables.)

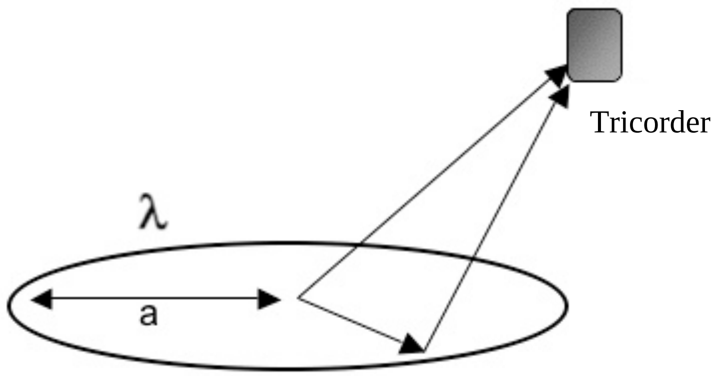


v. Express the Cartesian components of $\vec{\mathfrak{R}}$ using <u>spherical</u> coordinates.



Part 2 – Charged bike tires

In the year 2240, a bicyclist, named Thomas, gets lost east of Boulder. And he gets a flat tire. Thomas pulls off the tire and then consults his Tricorder to find out what life forms are nearby. However, the flat tire has somehow been charged with uniform charge density λ. The Tricorder complains that the electric field from the tire is very annoying.



Your goal is to calculate the electric field produced by the electrically-charged tire (ring of line-charge density λ).

i. The origin is at the center of the tire. Label the diagram with points (x,y,z) and (x',y',z')

ii. Now label the three vectors: $\vec{r}$, $\vec{r}\,'$, and $\vec{\mathfrak{R}}$ (where $\vec{\mathfrak{R}}$ is Griffiths' "script r").

iii. Write down a formal integral expression for the electric field. Be very explicit about *all* "short hand symbols" that appear in that integral (What does curly-R-hat mean here, specifically?) Looking back at part 1, which coordinate choice would be most convenient?)

iv. Manipulate your integral into a form that could (at least in principle) be solved by a dumb computer or calculator. Then, simplify by putting the Tricorder on the z-axis, and evaluate that integral!

(note: You have found the E-field caused by one **ring** of charge. Q.4 on HW.2 asks for the E-field caused by a charged **disc**. Hint: A disc is the sum of many rings. Did someone say "superposition"?)

v. Check the limits for very large *z*, and $z = 0$. Do these answers make sense? Make a sketch of E_z as a function of *z*, including both positive and negative *z* axes. Are the units correct for an electric field? Where should the Tricorder be placed to avoid interference from the electric field?

Challenge Problem:

Instead of a Tricorder, you now have a single electron. You release the electron on the z-axis, ever so slightly above (or below) the origin. It is free to respond to the Electric Field. What kind of motion will this electron experience? (What frequency of radiation would you expect to be emitted)?