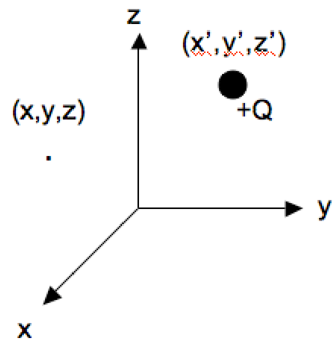
# Tutorial 1: The charged bike tire

## Part 1




There is a charge +Q at point (x',y',z').
We're concerned with the field at point (x,y,z).

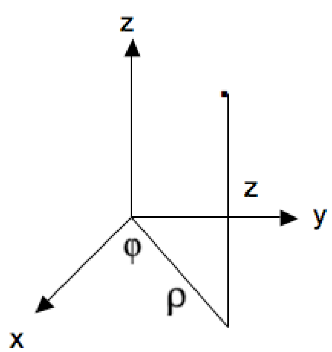
i. Draw on the graph:

$\vec{r}$  $\vec{r}'$  and  $\vec{\mathscr{r}}$

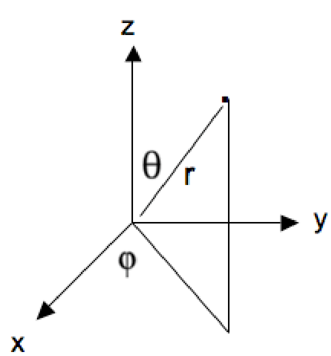
ii. Express $\vec{\mathscr{r}}$ in terms of $\vec{r}$ and $\vec{r}'$ .

iii. Now express the Cartesian (x, y, and z) components of $\vec{\mathscr{r}}$ in terms of the Cartesian components of $\vec{r}$ and $\vec{r}'$ .

iv. Express the Cartesian (x, y, and z) components of $\vec{\mathscr{r}}$ using <u>cylindrical</u> coordinates.




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





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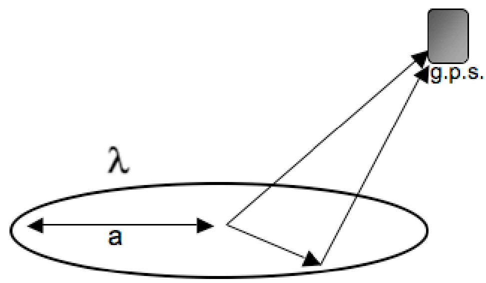
## Part 2

You're lost while riding your road bike east of Boulder. To make things worse, you suddenly get a flat. You pull the wheel off your bike, then consult your G.P.S. to figure out where you are. However, your flat has somehow been charged with charge density $\lambda$. The electric field produced by your charged tire is interfering with your G.P.S!

Your goal is to calculate the electric field produced by your electrically-charged tire (ring of line-charge density $\lambda$




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 $\vec{\mathscr{r}}$

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?)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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 g.p.s. 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? Are the units correct for an electric field? Where should you place your G.P.S. to avoid interference from the electric field?

vi. Is this situation physical or completely contrived? Ie., could a static electric charge interfere with a GPS?


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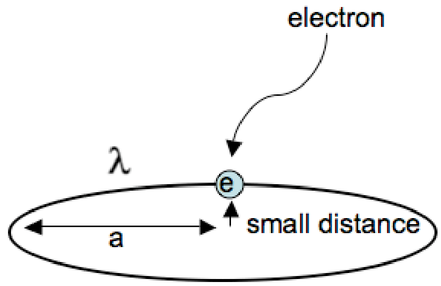
Challenge Problem:

Instead of a G.P.S. 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)?





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