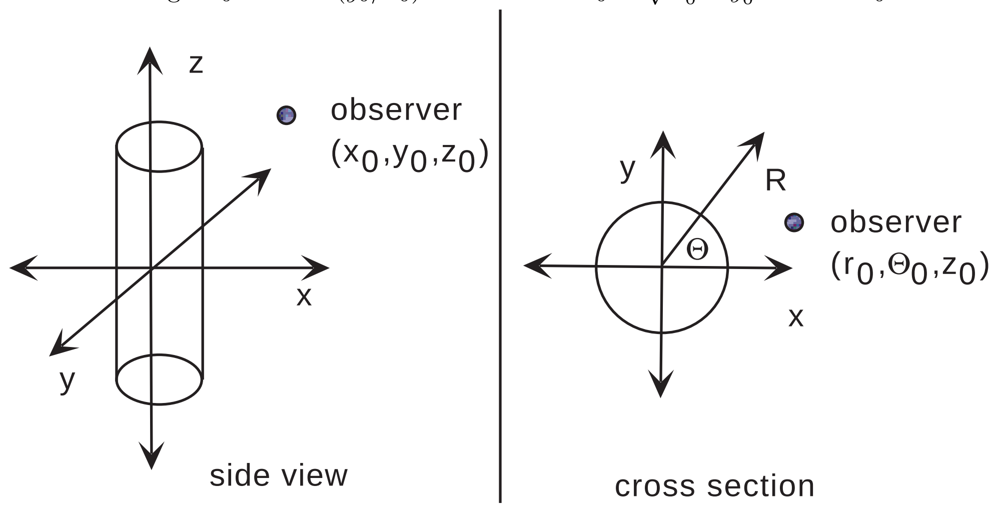
Name:

Gauss Law Activity

0.1 Infinitely Long Cylinder Consider the cylinder drawn below (except, consider it to be infinite!) and an observer of the cylinder at a given location x_0, y_0, z_0. (Note that this location can also be written in terms of an angle $\theta_0 = \tan^{-1}(y_0/x_0)$ and a radius $r_0 = \sqrt{x_0^2 + y_0^2}$ and the z_0 variable.)



1. If you close your eyes and the cylinder is moved along the x-axis, would you notice a difference when you open your eyes? (e.g. is it closer, further, at a different angle)?

2. If you close your eyes and the cylinder is moved along the y-axis, would you notice a difference when you open your eyes? (e.g. is it closer, further, at a different angle)?

3. If you close your eyes and the cylinder is moved along the z-axis, would you notice a difference when you open your eyes?

4. If you close your eyes and the cylinder is rotated (that is, θ is changed, would you notice a difference when you open your eyes?

5. If you close your eyes and the cylinder is moved radially outward (along any angle), would you notice a difference when you open your eyes? (e.g. closer, further, at a different angle)?

6. We define a symmetry variable as any of the cylinder variables that, when changed, does not change the appearance of the cylinder. What are the symmetry variables for the infinite cylinder?

7. We define all the other variables as non-symmetry variables. What are the non-symmetry variables for this cylinder?

8. Consider two test charges at the following locations

$$z = 5\text{cm}, r = 2\text{cm}, \theta = 0^o \quad \text{and} \quad z = 5\text{cm}, r = 2\text{cm}, \theta = 90^o$$

   How do the electric fields compare at those two locations? Explain.

9. Consider two test charges at the following locations:

$$z = 5\text{cm}, r = 2\text{cm}, \theta = 0^o \quad \text{and} \quad z = 5\text{cm}, r = 20\text{cm}, \theta = 0^o$$

   How do the electric fields compare at those two locations? Explain.

10. In general, would you expect the magnitude of the electric field to change as symmetry variables changed? as non-symmetry variables change? Explain.

11. Make a guess of the direction of the electric field for the cylinder. Sketch your guess on the drawing on the previous page, and illustrate it in 3 dimensions by using the styrofoam and wires.

12. If you change a symmetry variable (e.g. rotate the cylinder or move it along the z axis) does the direction of the electric field change? Should it change? Explain.

13. Based on the work on the last page, describe an imaginary surface (it can be curved, but it must be a surface and not a line) on which the cylinder's electric field is constant in magnitude. You may find it useful to use a sheet of paper to investigate and describe possible surfaces.

14. What is the angle between $\vec{E}$ and $\vec{A}$ on this surface?

15. Describe an imaginary surface through which there is no flux due to the cylinder's electric field. (Hint: when can the electric field and the area be non-zero, and yet there is no flux).

16. A useful Gaussian surface is closed surface for which we know that $\vec{E}$ is constant and the angle between $\vec{E}$ and $\vec{A}$ is constant, or on which the flux is zero, or a combination of the two. Verify that a round cookie tin surface, concentric with the cylinder, is a useful Gaussian surface for the infinite cylinder.

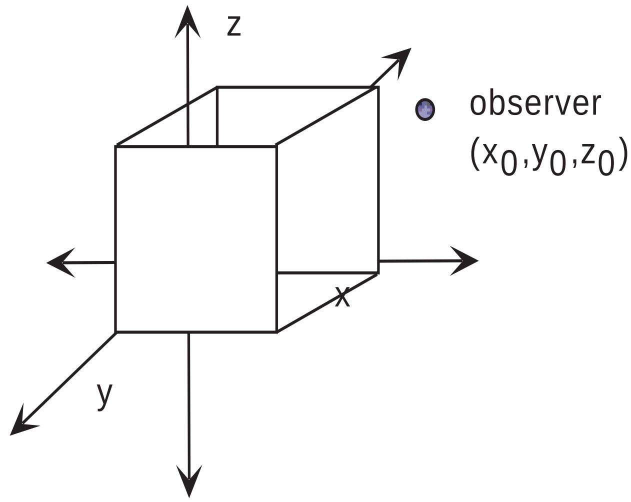
0.2 Sphere Now that you are familiar with the ideas, we will repeat the same questions (only much more quickly) for a sphere and a cube.

1. What are the symmetry variables for a sphere?

2. What imaginary surface has $\vec{E}_{\text{sphere}} = \text{constant}$?

3. What imaginary surface has a zero flux due to the sphere's electric field?

4. What is a useful gaussian surface for a sphere?



0.3 Cube

1. What are the symmetry variables for a cube?

2. What imaginary surface has $\vec{E}_{\text{cube}} = \text{constant}$?

3. What imaginary surface has a zero flux due to the cube's electric field?

4. What is a useful gaussian surface for a cube?