This unit explores integration scalar fields (typically charge and mass density) in 1-, 2-, and 3-dimensions and in rectangular, cylindrical, and curvilinear coordinates.

We will also explore vector line integrals in the context of work along non-trivial paths.

Questions we will explore: What are cylindrical and spherical coordinates? How do you use symmetry to choose an appropriate coordinate system. How are densities in different dimensions defined? How can you algebraically describe where charge and mass densities are zero. How do you use proportional reasoning to describe the functional dependence of a density? How do you use $d\vec{r}$ to describe chopping up curves, surfaces, and volumes? How do you choose limits of integration based on the geometry of a problem?

Key Activities/Problems

- Charge on a Parabola
- Charge on the Spiral

At the end of this unit, you should be able to:

- Choose a coordinate system appropriate for the symmetries of a physical system.
- Write down $d\vec{r}$ from memory in rectangular, cylindrical, and spherical coordinates.
- Use the "use what you know" strategy to evaluate $d\vec{r}$ along a path described in words or figures, even when that path is not along a "coordinate equals constant" curve.
- Integrate a charge or mass density in 1-, 2-, and 3-dimensions to get a total charge.
- Use step and delta functions to describe the location of charge and mass densities.
- Use a vector line integral in rectangular, cylindrical, and spherical coordinates to calculate the work done to move a test charge in an electrostatic field.