In this unit, you will explore how the gradient describes the relationship beween the electric field $\vec{E}(\vec{r})$ and the electrostatic potential $V(\vec{r})$ (or equivalently the gravitational field $\vec{g}(\vec{r})$ and the gravitational potential $\Phi(\vec{r})$) both geometrically and algebraically. You will also explore how to find the electric (and gravitational) field from a charge (or mass) source.

What does it mean to find rates of change (derivatives) of scalar fields in more than one spatial dimension? What is a vector field and how can we use vector fields to describe these derivatives? In what sense are electric and gravitational fields rates of change of their respective potentials? Given a source (charge or mass), how do you calculate the corresponding field?

Key Activities/Problems

- Electric Field of a Line Source from the Potential
- Drawing Electric Field Vectors for Discrete Charges
- Electric Field Due to a Ring of Charge

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

- Find the electric field $\vec{E}(\vec{r})$ from the electrostatic potential $V(\vec{r})$ or equivalently the gravitational field $\vec{g}(\vec{r})$ from the gravitational potential $\Phi(\vec{r})$ in rectangular, cylindrical, and spherical coordinates.
- Name and describe key features of the gradient of a scalar field using both geometric and algebraic reasoning.
- Use the superposition principle of electric fields to find the electric field from multiple sources or source densities, both graphically and algebraically.