

# SUMMARY

The goal of Chapter 30 has been to understand how the electric potential is connected to the electric field.

## GENERAL PRINCIPLES

### Connecting $V$ and $\vec{E}$

The electric potential and the electric field are two different perspectives of how source charges alter the space around them.  $V$  and  $\vec{E}$  are related by

$$\Delta V = V(s_f) - V(s_i) = -\int_{s_i}^{s_f} E_s ds$$

where  $s$  is measured from point  $i$  to point  $f$  and  $E_s$  is the component of  $\vec{E}$  parallel to the line of integration.

Graphically

$\Delta V =$  the negative of the area under the  $E_s$  graph

and

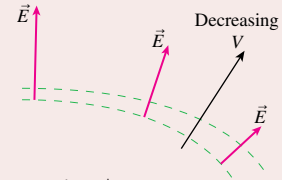
$$E_s = -\frac{dV}{ds}$$

$=$  the negative of the slope of the potential graph.

### The Geometry of Potential and Field

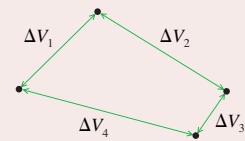
The electric field

- Is perpendicular to the equipotential surfaces.
- Points “downhill” in the direction of decreasing  $V$ .
- Is inversely proportional to the spacing  $\Delta s$  between the equipotential surfaces.



### Conservation of Energy

The sum of all potential differences around a closed path is zero.  $\sum(\Delta V)_i = 0$ .

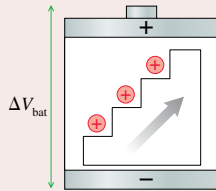


## IMPORTANT CONCEPTS

A **battery** is a **source of potential**. The charge escalator in a battery uses chemical reactions to move charges from the negative terminal to the positive terminal.

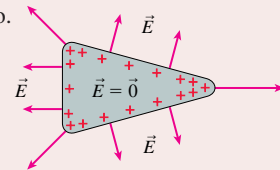
$$\Delta V_{\text{bat}} = \mathcal{E}$$

where the emf  $\mathcal{E}$  is the work per charge done by the charge escalator.



For a **conductor in electrostatic equilibrium**

- The interior electric field is zero.
- The exterior electric field is perpendicular to the surface.
- The surface is an equipotential.
- The interior is at the same potential as the surface.



## APPLICATIONS

### Resistors

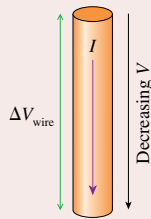
A potential difference  $\Delta V_{\text{wire}}$  between the ends of a wire creates an electric field inside the wire

$$E_{\text{wire}} = \frac{\Delta V_{\text{wire}}}{L}$$

The electric field causes a current

$$I = \frac{\Delta V_{\text{wire}}}{R}$$

where  $R = \frac{\rho L}{A}$  is the wire's **resistance**.



### Capacitors

The **capacitance** of two conductors charged to  $\pm Q$  is

$$C = \frac{Q}{\Delta V_C}$$

The energy stored in a capacitor is

$$U_C = \frac{1}{2} C (\Delta V_C)^2$$

#### Series capacitors

$$C_{\text{eq}} = \left( \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots \right)^{-1}$$

#### Parallel capacitors

$$C_{\text{eq}} = C_1 + C_2 + C_3 + \dots$$

