Outline of Chapter

- **Electric Potential Energy** & **Potential Difference**
- Relation between **Electric Potential** & **Electric Field**
- **Electric Potential** Due to **Point Charges**
- **Potential** Due to **Any Charge Distribution**

- **Equipotential** Surfaces
- **Electric Dipole Potential**
- **E** Determined from ***V***
- **Electrostatic Potential Energy**; the Electron Volt
- Cathode Ray Tube: TV & Computer Monitors, Oscilloscope

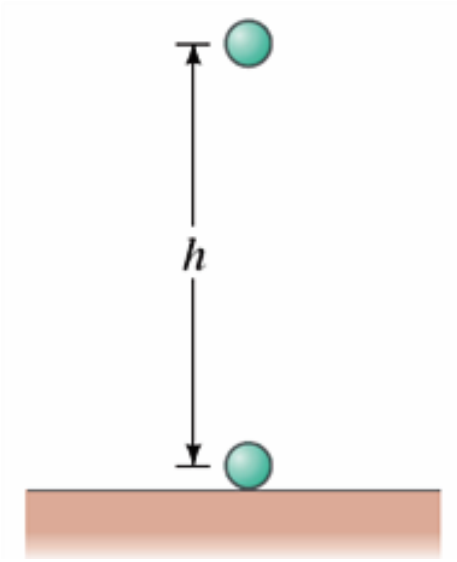
Brief Review of Some Physics I Concepts

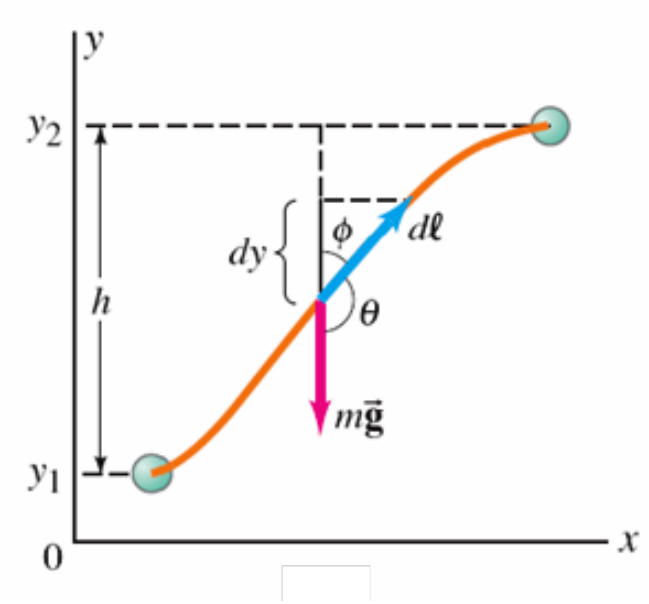
Definition

A force is **conservative** if & only if

the work done by that force on an object moving from one point to another depends ONLY on the initial & final positions of the object, & is independent of the particular path taken.

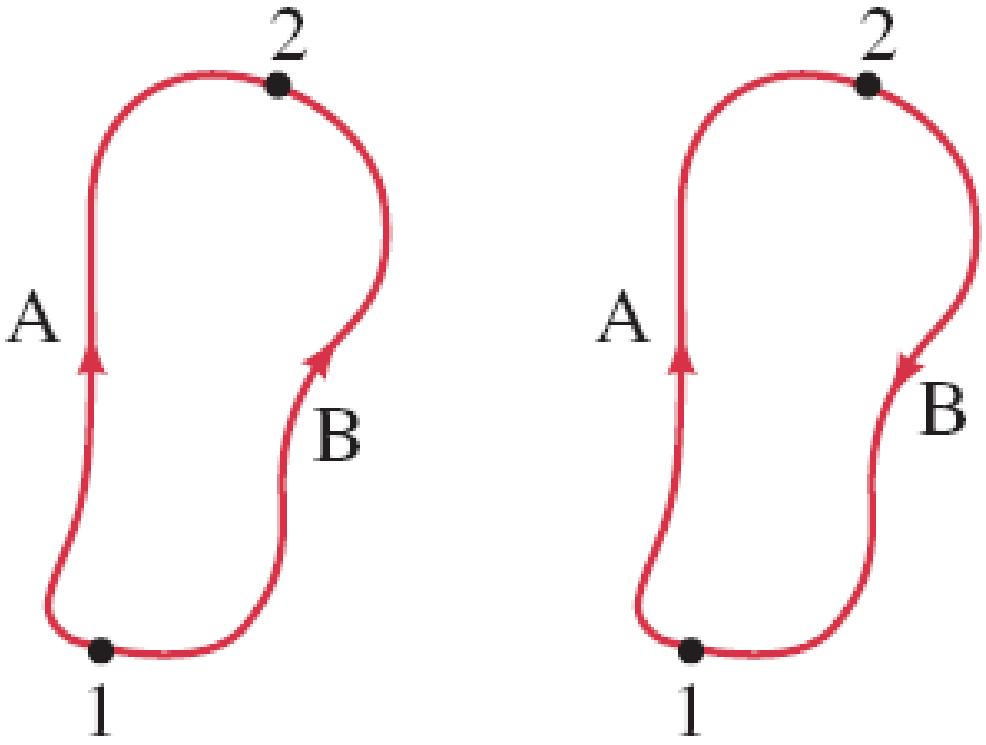
Example: Gravity





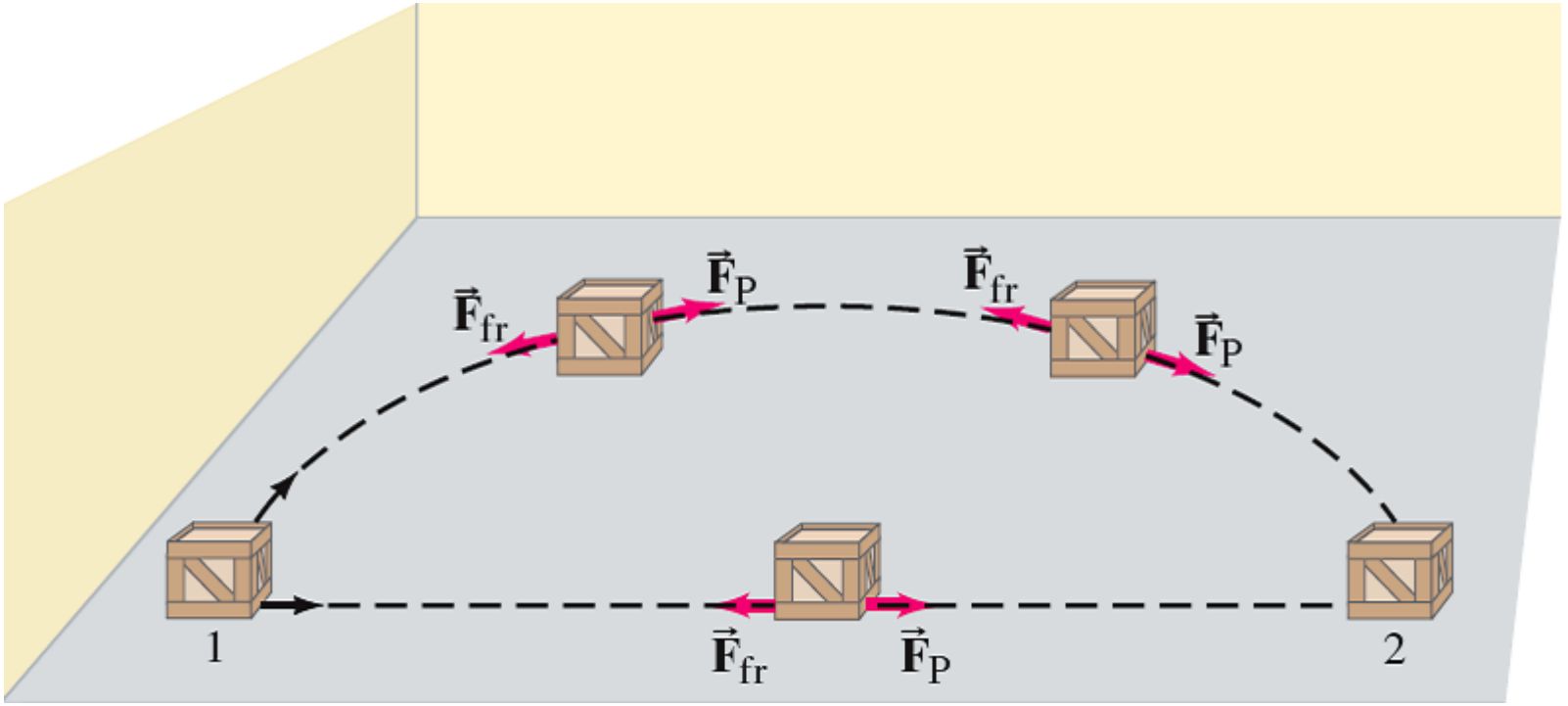
Conservative Force: Another definition:

A force is conservative if the net work done by the force on an object moving around any closed path is zero.



If **friction** is present, the work done depends not only on the starting & ending points, but also on the path taken.

Friction is a Nonconservative Force!



Friction is a Nonconservative Force.

The work done by friction depends on the path!

Potential Energy

- A mass can have a ***Potential Energy*** due to its environment.

Potential Energy **(U)** ?

The energy associated with *the position or configuration* of a mass.

Examples of systems with **Potential Energy:**

- A wound-up spring
- A stretched elastic band
- An object at some height above the ground

TABLE 8–1 Conservative and Nonconservative Forces	
Conservative Forces	**Nonconservative Forces**
Gravitational	Friction
Elastic	Air resistance
Electric	Tension in cord
	Motor or rocket propulsion
	Push or pull by a person

Potential Energy:

Can only be defined for

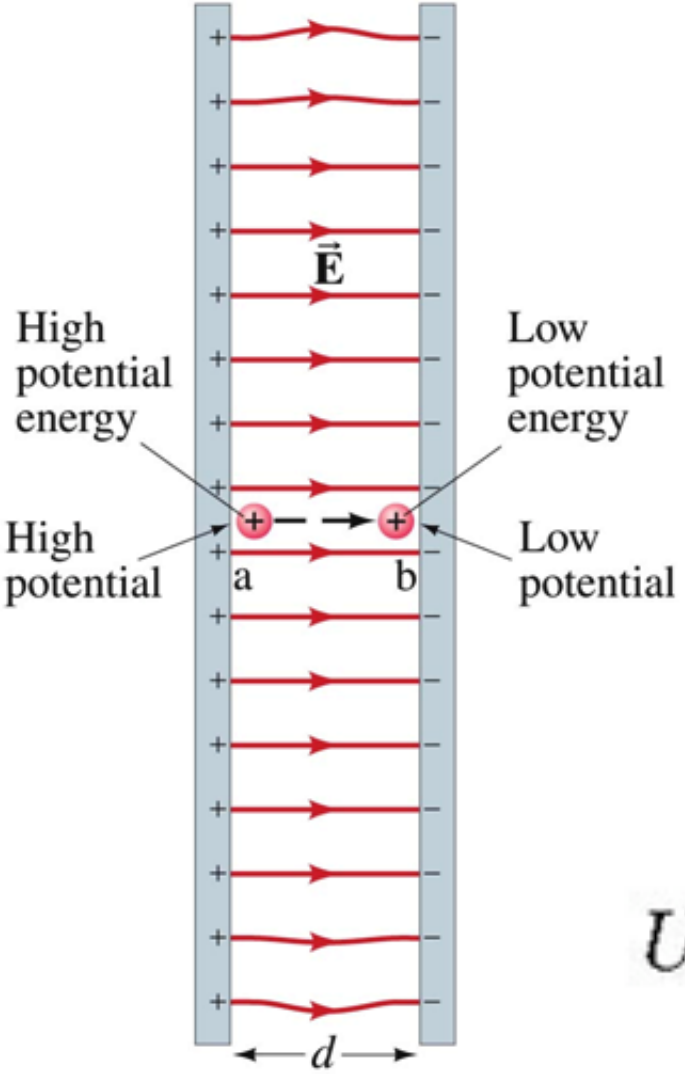
Conservative Forces!

Another **Physics I Result**

The change in the Potential Energy is defined to be the negative of the work done by the conservative force.

End of *Brief Review!!*

Electrostatic Potential Energy, Potential Difference



The **Electrostatic Force** is ***Conservative***

? So an **Electrostatic Potential Energy** can be defined.

As in Physics I, in this case, **the change in the electric potential energy is negative of work done by electric force:**

$$U_b - U_a = -W = -qEd.$$

The Electric Potential V *is defined*

as potential energy per unit charge:

$$V_a = \frac{U_a}{q}.$$

The SI Unit of **Electric Potential** is

The Volt **(V). 1 V = 1 J/C.**

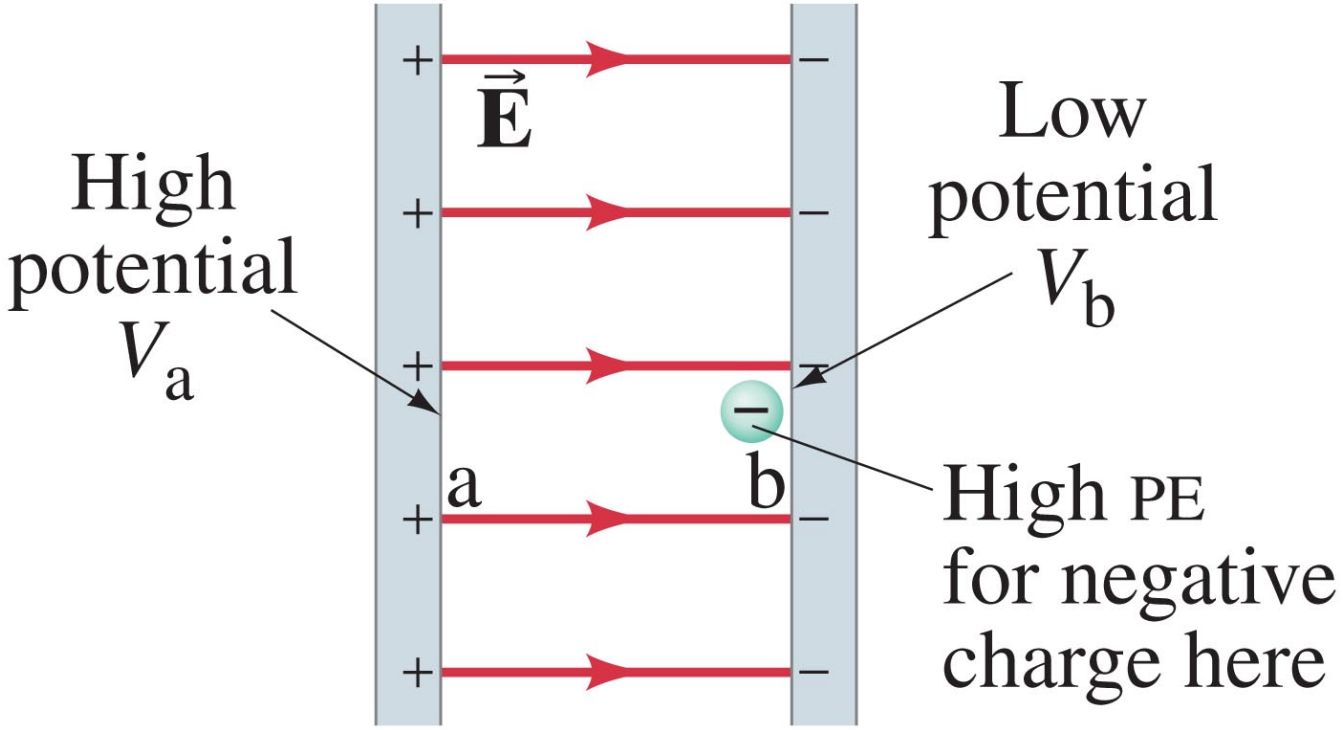
Only *changes* in potential can be measured,

so we can arbitrarily choose the point where **V = 0**.

$$V_{ba} = \Delta V = V_b - V_a = \frac{U_b - U_a}{q} = -\frac{W_{ba}}{q}.$$

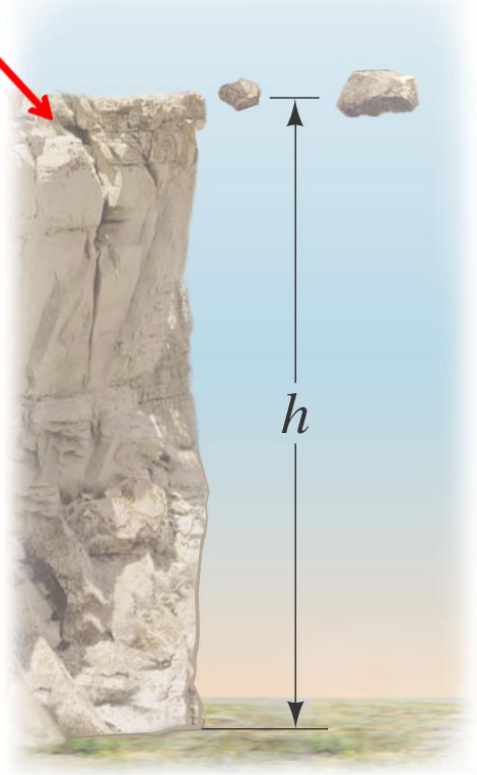
Conceptual Example: A negative charge.

Suppose a negative charge, such as **an electron**, is placed near the negative plate at point **b**, as shown here. If the electron is free to move, will its electric potential energy increase or decrease? How will the electric potential change?

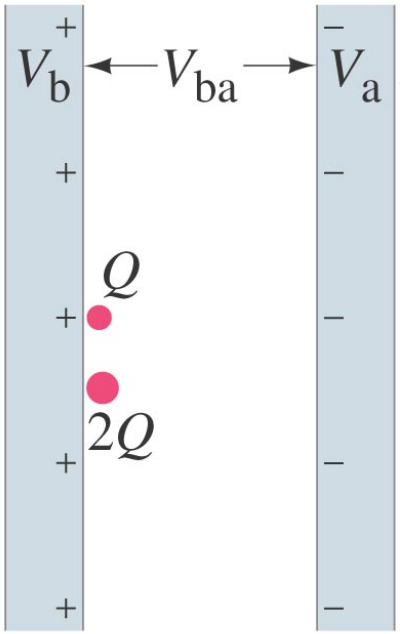


Analogy between Gravitational Potential Energy & Electrical Potential Energy

2 masses **m** & **2m**, at the same height have gravitational potential energies $U_1 = mgh$, $U_2 = 2mgh$. So clearly, $U_2 = 2U_1 > U_1$



2 charges **Q** & **2Q**, are at the same electric potential V_{ba} but they have different electric potential energies $U_1 = QV_{ba}$, $U_2 = 2QV_{ba}$. So clearly, $U_2 = 2U_1 > U_1$



Electrical Sources such as batteries and generators supply a constant potential difference. Here are some typical potential differences, both natural and manufactured:

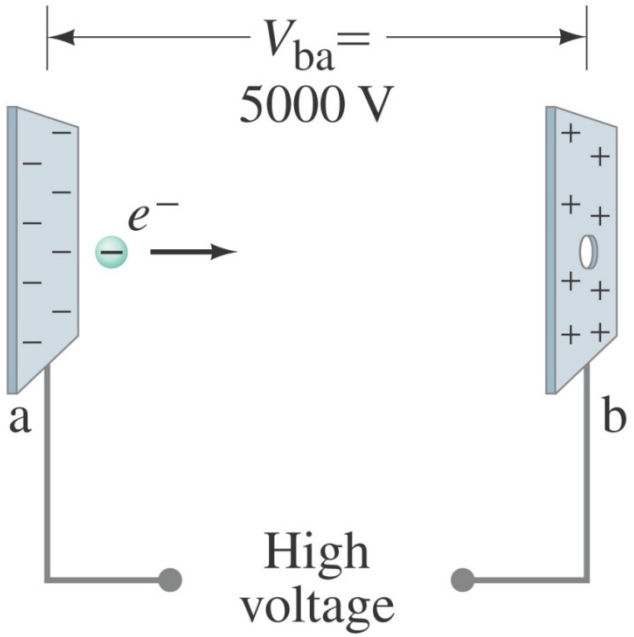
TABLE 23–1 Some Typical Potential Differences (Voltages)

Source	Voltage (approx.)
Thundercloud to ground	10^8 V
High-voltage power line	10^5–10^6 V
Power supply for TV tube	10^4 V
Automobile ignition	10^4 V
Household outlet	10^2 V
Automobile battery	12 V
Flashlight battery	1.5 V
Resting potential across nerve membrane	10^{-1} V
Potential changes on skin (EKG and EEG)	10^{-4} V

Example
Electron in a CRT

An electron in a cathode ray tube (CRT) is accelerated from rest through a potential difference

$$V_b - V_a = V_{ba} = +5{,}000\ \text{V}$$



Calculate:

(a) The change in electric potential energy of the electron.

(b) The speed of the electron ($m = 9.1 \times 10^{-31}$ kg) as a result of this acceleration.