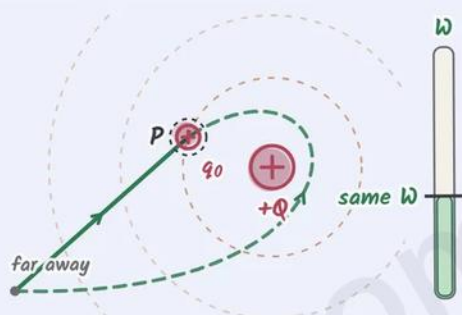


# Electrostatic Potential and Capacitance

energy per charge, and the device that stores it

## Potential, and why it exists at all

- the electrostatic force is **conservative**: the work it does between two points is independent of the path, so a potential energy can be defined
- potential  $V$  at a point is the work done per unit positive charge in bringing it from infinity to that point, **without acceleration**
- it is a **scalar**, far easier to handle than the field; unit the volt, one joule per coulomb
- $V = (1/4\pi\epsilon_0) q/r$  for a point charge, and it carries the **SIGN** of the charge, so a negative charge gives a negative potential
- potentials from several charges add **algebraically**, with no components and no angles



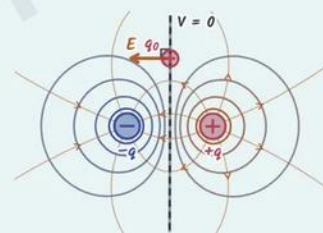
two paths in from far away, the same work:  $V$  at  $P$  is fixed

## Equipotential surfaces

- a surface on which the potential has the same value everywhere, so **no work is done moving a charge along it**
- they are **always perpendicular to the field lines**, since any component of  $E$  along the surface would do work
- for a point charge they are concentric spheres; for a uniform field, parallel planes; for a dipole, a set of surfaces symmetric about the axis
- they are **closer together where the field is stronger**, because  $V$  changes faster there
- two equipotential surfaces never intersect, for the same reason two field lines never do



spheres round a charge, crowded near it where  $E$  is strong



a dipole: the equator is the surface  $V = 0$

## The relations between field, potential and energy

field from potential

$$E = -dV/dr, \text{ the field points toward falling potential}$$

work done

$$W = q (V_A - V_B) \text{ for the work done BY THE FIELD moving from A to B}$$

potential of a dipole

$$V = (1/4\pi\epsilon_0) p \cos \theta / r^2, \text{ and ZERO everywhere on the equatorial plane}$$

energy of two charges

$$U = (1/4\pi\epsilon_0) q_1 q_2 / r$$

dipole in a field

$$U = -pE \cos \theta$$

energy density of a field

$$u = (1/2) \epsilon_0 E^2, \text{ joules per cubic metre}$$

the minus sign in  $E = -dV/dr$  is the physics, not a convention: a positive charge released from rest moves toward **LOWER** potential