

Electromagnetism

GRE · GRE Subject Test · GRE Physics

Zero electric potential at a point does not imply zero electric field there.

Prerequisites: 13, 14, 15, 29, 30.

- Use electrostatic potentials, fields and Gauss's law
- Analyse circuits, magnetism and induction
- Apply Maxwell equations and electromagnetic wave relationships

Choose the system and model

Electric field is the negative gradient of potential. A value and a spatial change are different quantities.

Use the governing relation

Use Gauss's law with symmetry. A known total flux alone does not give the field at every surface point.

Apply the conditions

Kirchhoff's laws track charge and energy in circuits. Induced emf follows changing magnetic flux with the Lenz-law sign.

Check the conclusion

Maxwell equations link electric and magnetic fields. In vacuum a wave has $E/B=c$ and carries energy.

Worked method

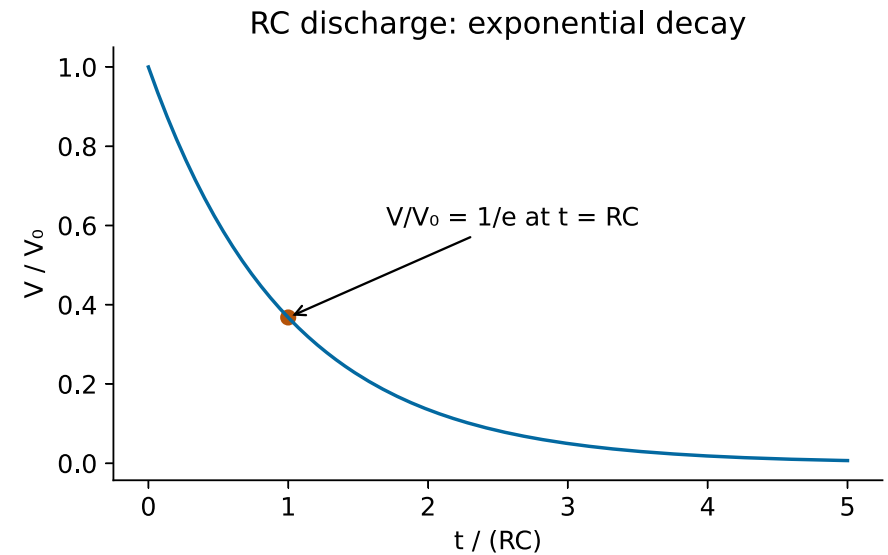
A spherical shell has radius R and uniform charge Q . Choose zero potential at infinity. Spherical symmetry lets Gauss's law determine the field outside.

$$4\pi r^2 E = Q/\epsilon_0, \quad E = Q/(4\pi\epsilon_0 r^2) \quad (r > R).$$

Inside, enclosed charge is zero and symmetry gives $E = 0$. Continuity gives

$$V(r) = \begin{cases} Q/(4\pi\epsilon_0 R) & r \leq R, \\ Q/(4\pi\epsilon_0 r) & r > R. \end{cases}$$

The potential is nonzero and constant inside. A zero gradient, rather than a zero value, gives a zero field. The radial field jumps at the charged surface.



Electromagnetism: original GRE teaching diagram.

Check conditions and vocabulary

Do not use Gauss's law to claim a uniform field on an arbitrary nonsymmetric surface.

flux: The surface integral of a field's normal component.

potential: Potential energy per unit charge.