

Electromagnetism

GRE undergraduate preparation · local supported objectives

Choose the physical question

Reasoning

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

Reasoning

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

Use the governing relation

Reasoning

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

Apply the conditions

Reasoning

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

Check the conclusion

Reasoning

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

Worked reasoning 1

Reasoning

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.

Worked relation 2

Reasoning

Apply this relation only under the conditions just stated.

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

Worked reasoning 3

Reasoning

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

Worked relation 4

Reasoning

Apply this relation only under the conditions just stated.

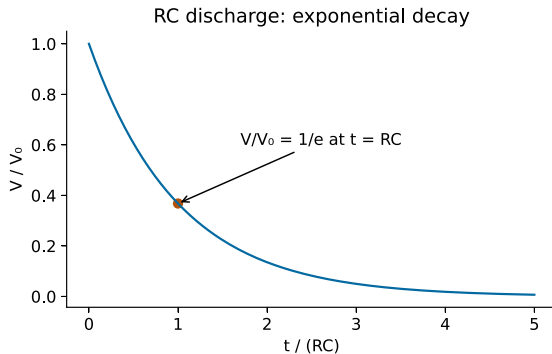
$$V(r) = \begin{cases} Q/(4\pi\epsilon_0 R) & r \leq R, \\ Q/(4\pi\epsilon_0 r) & r > R. \end{cases}$$

Worked reasoning 5

Reasoning

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.

Read the original diagram



- Original GRE teaching diagram: Electromagnetism
- Identify the axes, units, directions and the stated model.

Independent transfer · attempt

Reasoning

Two concentric thin spherical shells have radii R and $2R$, and charges Q and $-Q$. Derive E and V in all three radial regions, with zero potential at infinity. Check continuity of V at both shells. **[6]**

Independent transfer · reasoning

Reasoning

Let $k = 1/(4\pi\epsilon_0)$ and positive field mean radially outward. For $r < R$, $E = 0$ and $V = kQ/R - kQ/(2R) = kQ/(2R)$. For $R < r < 2R$, $E = kQ/r^2$ and $V = kQ/r - kQ/(2R)$. For $r > 2R$, both E and V are zero. At R the two potentials give $kQ/(2R)$; at $2R$ they give zero. Normal E jumps at the surface charges. Award each region's pair one mark, each continuity check one, and field-jump interpretation one.

Check assumptions and limits

Reasoning

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

Keep the technical distinctions

Reasoning

flux : The surface integral of a field's normal component. potential :
Potential energy per unit charge.

Check yourself

- Define flux and give its condition of use.
- Define potential and give its condition of use.
- Redo the original transfer with a changed parameter; check a limiting case.