# MAXWELL'S EQUATIONS

Look at our full set of Maxwell's equations so far:

$$\nabla \bullet \mathbf{E} = \rho / \varepsilon_0 \qquad \nabla \bullet \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J}$$

What is $\nabla \bullet \left( \nabla \times \mathbf{B} \right)$?

A) zero
B) non-zero
C) Could be either
D) Could be BOTH at the same time
E) My brain hurts!

Ampere/Maxwell's law:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \partial \mathbf{E} / \partial t$$

A capacitor is charging. (Neglect "edge effects")

What is $\iint (\nabla \times \mathbf{B}) \bullet d\mathbf{a}$

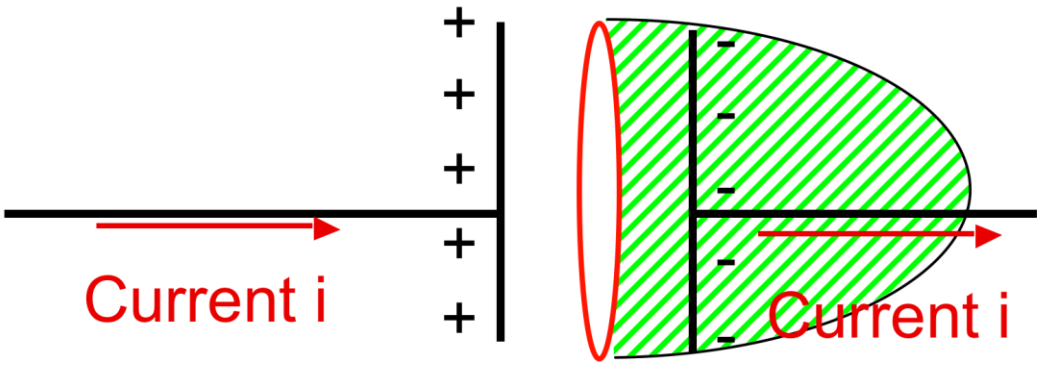
over the green hatched area shown?

A) 0

B) $\mu_0$ i

C) Complicated

D) I'm flummoxed



# Ampere/Maxwell's law:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \partial \mathbf{E} / \partial t$$

A capacitor is charging. (Neglect "edge effects")

What is $\iint (\nabla \times \mathbf{B}) \bullet d\mathbf{a}$

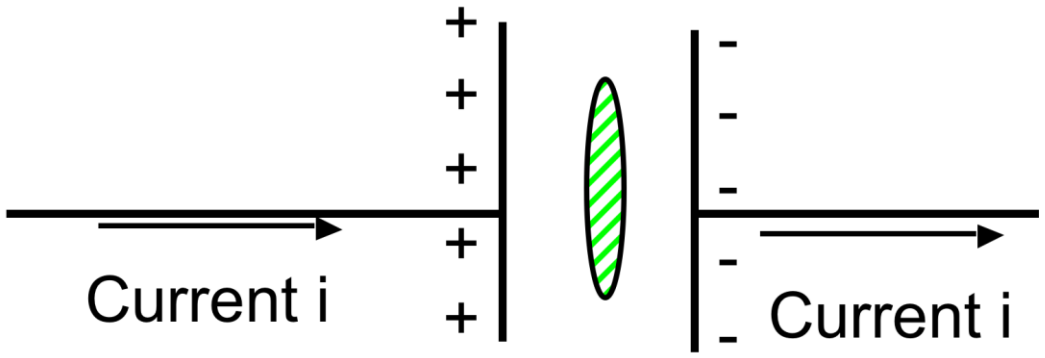
over the green hatched area (spans same loop as before)?

A) 0

B) $\mu_0$ i

C) Complicated

D) I'm still flummoxed



# Maxwell's equations:

$$\nabla \bullet \mathbf{E} = \rho / \varepsilon_0 \qquad \nabla \bullet \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial \mathrm{t} \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \partial \mathbf{E}/\partial \mathrm{t}$$

In vacuum, what is $\nabla \times (\nabla \times \mathbf{E})$?

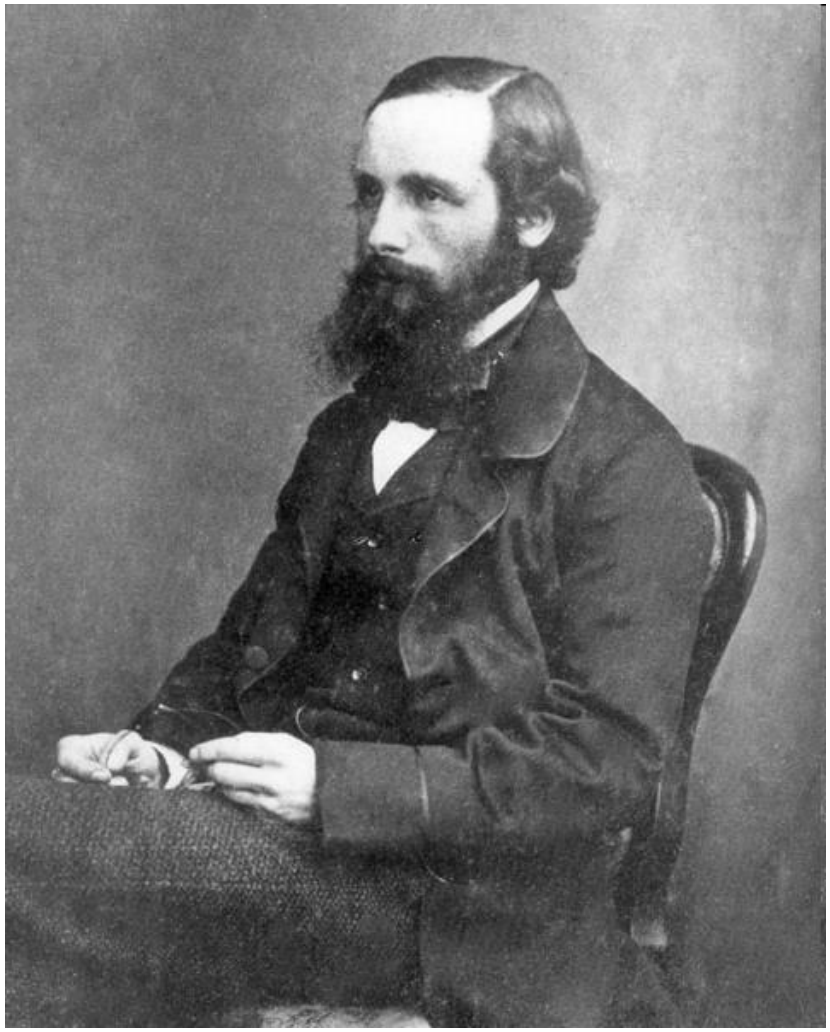
$$\nabla \times (\nabla \times \mathbf{E}) = \nabla (\nabla \bullet \mathbf{E}) - \nabla^2 \mathbf{E}$$

$$\nabla \times (\nabla \times \mathbf{E}) = \nabla \times (-\partial \mathbf{B}/\partial \mathrm{t}) = -\partial (\nabla \times \mathbf{B})/\partial \mathrm{t}$$

Wave Equation !!

$$-\nabla^2 \mathbf{E} = -\frac{1}{c^2}\frac{\partial^2}{\partial t^2}\mathbf{E}$$

$$\mathbf{E} = \mathbf{E}_0 e^{i(\mathbf{k}\bullet\mathbf{r} - \omega t)}$$



# James Clerk Maxwell
# Scottish 1831-1879

"From a long view of the history of mankind – seen from, say, ten thousand years from now – there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics. The American Civil War will pale into provincial insignificance in comparison with this important scientific event of the same decade."

– R.P. Feynman

**James Clerk Maxwell**
(1831 – 1879) Scottish scientist. First Cavendish laboratory professor at Cambridge.

Most famous for complete formulation of laws of electromagnetism, predicting EM waves

Also important work on kinetic theory and thermodynamics of gases, control engineering, color vision.

First to introduce labs for undergraduates!

First durable colour photographic image, demonstrated by James Clerk Maxwell in an 1861 lecture

In the millennium poll—a survey of the 100 most prominent physicists—Maxwell was voted the third greatest physicist of all time, behind Newton and Einstein.