

Mar 30

Get clickers

Midterm is Wednesday
Practice exam is on website.

Gauss' Law

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{in}}{\epsilon_0}$$

|
flux

Ponderable: Gauss' Law exercises

Not Another Law!

Discussion: Gauss' Law for Magnetism

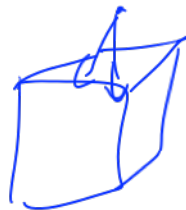
$$\oint \vec{B} \cdot d\vec{a} = 0$$

↳ no magnetic charges
(monopoles)

no point sources
for $\vec{B}$.

Ponderable: Outside the box

Reflux

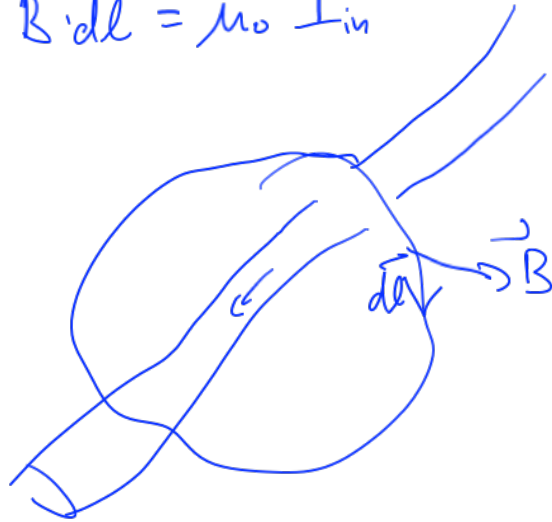


$$\oint \vec{E} \cdot d\vec{a}$$

↑
vector
pointing
out
of
volume

Discussion: Ampere's Law

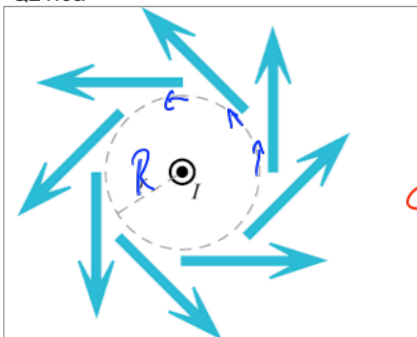
$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{in}$$



Ponderable: Ampere's Law and EMField

Clickers: Ampere's Law

Q21.6a

 The diagram shows a dashed circle of radius R with a central dot and a cross symbol, indicating a current I directed into the page. Eight blue arrows radiate outwards from the circle, representing a uniform magnetic field B. A small blue arrow on the dashed circle indicates a counter-clockwise path for integration.	$R = 3 \text{ cm}$, $B = 1\text{e-}5 \text{ T}$ What is I? A) 0 A B) $1.9\text{e-}1 \text{ A}$ C) $1.9\text{e-}6 \text{ A}$ <u>D) 1.5 A</u> E) 19 A
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$$\oint \vec{B} \cdot d\vec{\ell}$$

$$= B \int d\ell$$

$$= B 2\pi R = \mu_0 I$$

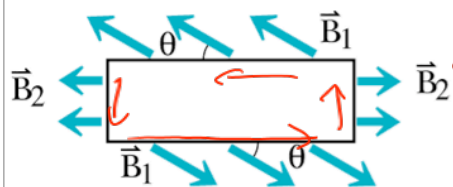
$$I = \frac{2\pi R B}{\mu_0}$$

$$\mu_0 = 4\pi \times 10^{-7}$$

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{in}$$

Q21.6b

$\theta = 30^\circ$, $B_1 = 2 \times 10^{-4} \text{ T}$, $B_2 = 1 \times 10^{-4} \text{ T}$
Width = 0.5 m, Height = 0.2 m

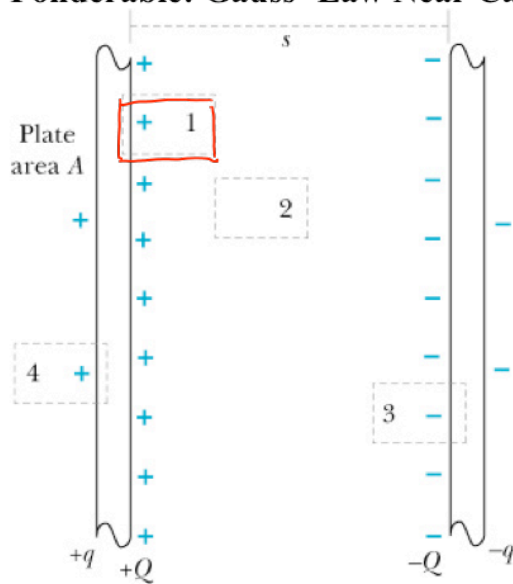


What is $\oint \vec{B} \cdot d\vec{l}$?

- A) $0 \text{ T} \cdot \text{m}$
- B) $8.7 \times 10^{-5} \text{ T} \cdot \text{m}$
- C) $1.7 \times 10^{-4} \text{ T} \cdot \text{m}$
- D) $2.0 \times 10^{-4} \text{ T} \cdot \text{m}$
- E) $2.1 \times 10^{-4} \text{ T} \cdot \text{m}$

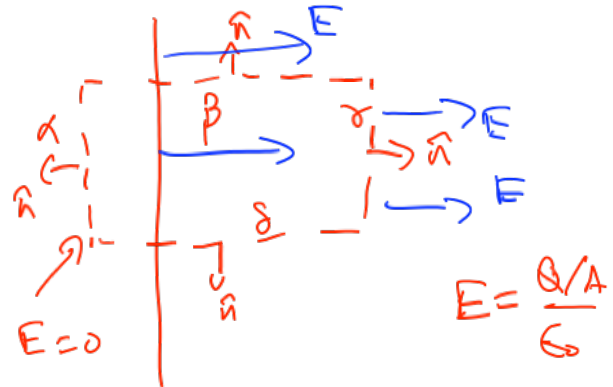
$$\begin{aligned}
 \oint \vec{B} \cdot d\vec{l} &= \int_{\text{bottom}} \vec{B} \cdot d\vec{l} + \int_{\text{right}} \vec{B} \cdot d\vec{l} + \int_{\text{top}} \vec{B} \cdot d\vec{l} + \int_{\text{left}} \vec{B} \cdot d\vec{l} \\
 &= |B|W \cos \theta + 0 + |B|W \cos \theta + 0 \\
 &= 2W|B| \cos \theta \\
 &= 2 \times 0.5 \times 2 \times 10^{-4} \cos 30^\circ = 1.7 \times 10^{-4} \text{ T} \cdot \text{m}
 \end{aligned}$$

Ponderable: Gauss' Law Near Capacitor



Shoebox or cylinder

$$\oint \vec{E} \cdot \hat{n} da = \frac{\oint_{\text{enc}}}{\epsilon_0}$$



$$\left. \begin{aligned} \int_{\alpha} \vec{E} \cdot \hat{n} da &= 0 \Rightarrow \text{no E inside conductor} \\ \int_{\beta, \gamma} \vec{E} \cdot \hat{n} da &= 0 \quad \vec{E} \cdot \hat{n} = 0 \quad \left| \quad \int_{\gamma} \vec{E} \cdot \hat{n} da = EA = \frac{Q}{\epsilon_0} \right. \end{aligned} \right\}$$

Tangible: Ampere's Law for Solenoid



$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

$$\int_{\text{top}} \vec{B} \cdot d\vec{l} + \int_{\text{side}} \vec{B} \cdot d\vec{l} + \int_{\text{side}} \vec{B} \cdot d\vec{l} + \int_{\text{bottom}} \vec{B} \cdot d\vec{l} = \mu_0 I$$

(Note: The side and bottom integrals are crossed out with red lines, with annotations $\vec{B} \cdot d\vec{l} = 0$ and $\vec{B} = 0$ respectively.)

$$B \cdot L = \mu_0 I_{\text{in}}$$

$$= \mu_0 I N$$

$$B = \frac{\mu_0 N I}{L} = \mu_0 I (N/L)$$