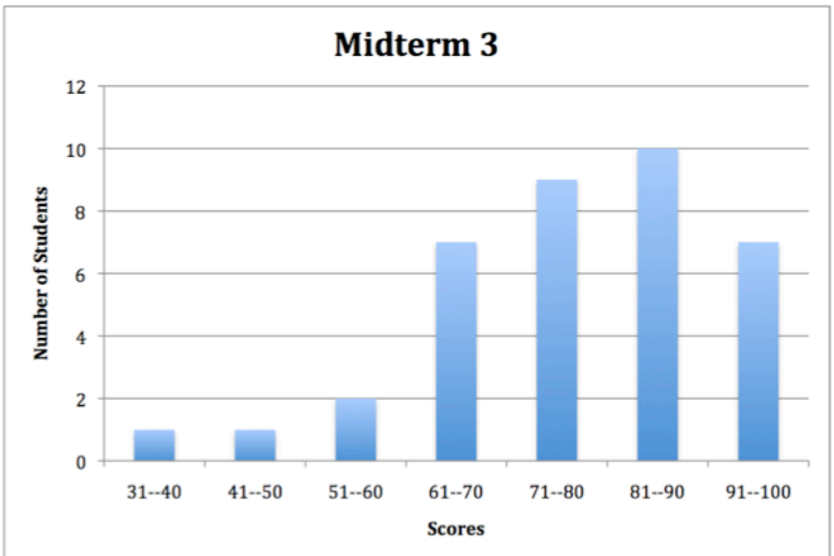
Apr 3

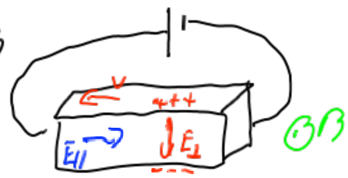
Get clickers



Mean: 77
Median: 80
Std Dev: 14

Exam 3

9)



$$qvB = qE = q\frac{\Delta V}{L}$$

$$v = \frac{\Delta V}{BL} = .01 \, m/s$$

$$t = \frac{d}{v} = 18 \, s$$

$$v = \mu E \rightarrow \mu = \frac{v}{E} = \frac{vd}{\Delta V} = .0012$$

$$I = qnAv \rightarrow n =$$

7)

a) $\int_r \vec{B}\cdot d\vec{l} = B_r l_r = 5.2\,e^{-6}\ T\cdot m$

b) $\int_l \vec{B}\cdot d\vec{l} = -B_l l_l = -2.52\,e^{-5}\ T\cdot m$

c) $\int_3 \vec{B}\cdot d\vec{l} = 0$

$\oint \vec{B}\cdot d\vec{l} = -2\,e^{-5}\ T\cdot m = \mu_0 I_{inc}$

$I_{inc} = 1.6\,A$ R

Discussion: Coulombic and Non-Coulombic Electric Fields

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{|\vec{r}|^2}\hat{r}$$ Coulomb's law

↳ $\oint \vec{E}\cdot\hat{n}\,dA = \frac{\sum q_i}{\epsilon_0}$ Gauss' Law

divergence field

$\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0$

$\vec{\nabla}\times\vec{E} = 0$

true for stationary charges

$\Delta V_{\text{round path}} = 0 = -\oint \vec{E}\cdot d\vec{l}$

↳ no "curly" part of $\vec{E}$

Moving charges

$$\vec{B} = \frac{\mu_0}{4\pi} q\frac{\vec{v}\times\hat{r}}{|\vec{r}|^2}$$ Biot-Savart Law

$\oint \vec{B}\cdot d\vec{l} = \mu_0 \sum I_{in}$ ← curly part of B

$\oint \vec{B}\cdot\hat{n}\,dA = 0$ ← no divergence

E field for stationary charges — has divergence but no curlyness

B field — has curl but no divergence

$$\Delta V = -\oint \vec{E}\cdot d\vec{l} = 0$$

Coulombic E field

no curly E field

$$\Delta V_{\text{round trip}} = \oint \vec{E}\cdot d\vec{l} = \frac{d\Phi_B}{dt}$$

Non-coulombic field

Φ_B is magnetic flux through surface surrounded by path look integral around

Flux can change in two ways

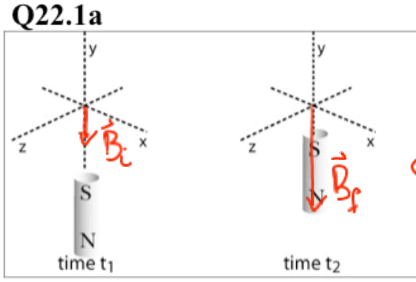
Change surface or change B

$$\Phi_B = \int_S \vec{B} \cdot \hat{n}\, dA$$

$$\oint_C \vec{E} \cdot d\vec{\ell} = -\frac{d}{dt}\left[\int_S \vec{B} \cdot \hat{n}\, dA\right]$$

Clickers: Changing B Field

Q22.1a



At the origin, what is the direction of $\Delta\vec{B}$?

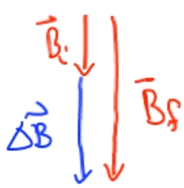
A) +y

B) –y

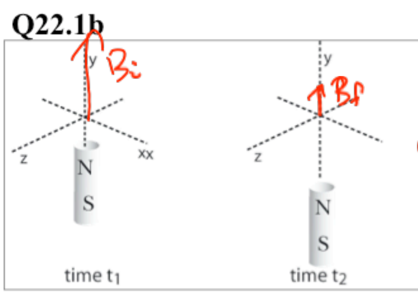
C) +z

D) –z

E) zero magnitude



Q22.1b



At the origin, what is the direction of $-\Delta\vec{B}/\Delta t$?

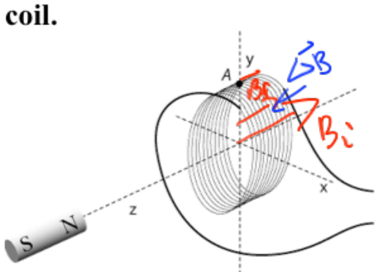
A) +y
B) –y
C) +z
D) –z
E) zero magnitude

B_i ↑ $\Delta\vec{B}$ ↓ B_f ↑

$\frac{\Delta\vec{B}}{\Delta t}$ ↓

$-\frac{\Delta B}{\Delta t}$ ↑

Q22.1c

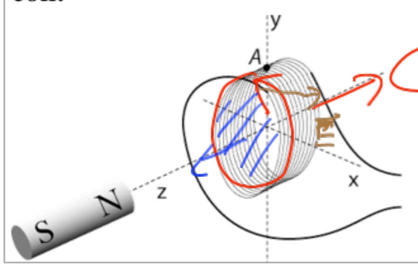
The magnet is moving in the +z direction, away from the coil. 	**At the origin (inside the coil), what is the direction of $-d\vec{B}/dt$?** **A) +y** **B) –y** **C) +z** **D) –z** **E) zero magnitude**

$\frac{d\vec{B}}{dt}$ in $+\hat{z}$

$\Rightarrow -\frac{d\vec{B}}{dt} = -\hat{z}$ dir

Q22.1d

The magnet is moving in the +z direction, away from the coil.



At location A, on the y-axis, inside the wire, what is the direction of the non-Coulomb electric field?

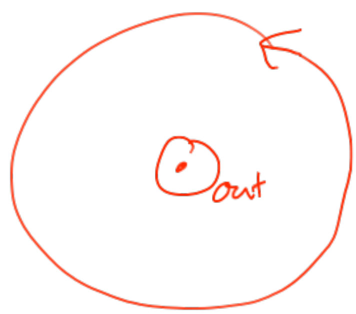
A) +x
B) –x
C) +y
D) –z
E) zero magnitude

$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$$

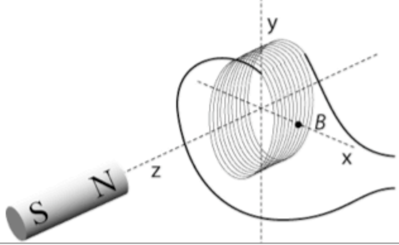
negative

$$\hat{n}\cdot\left(-\frac{d\vec{B}}{dt}\right)$$

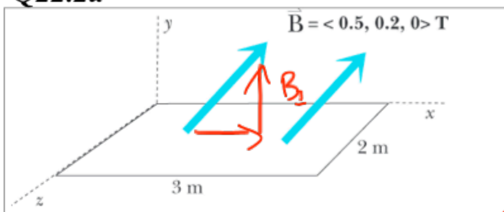
$+\hat{z}$ $\quad$ $-\hat{z}$ $\quad$ $-\#$



Q22.1e

The magnet is moving in the –z direction, toward the coil. 	**At location B, on the x-axis, inside the wire, what is the direction of the non-Coulomb electric field?** **A) +x** **B) +y** **C) –y** **D) +z** **E) zero magnitude**

Q22.2a



What is the magnetic flux through the rectangle?

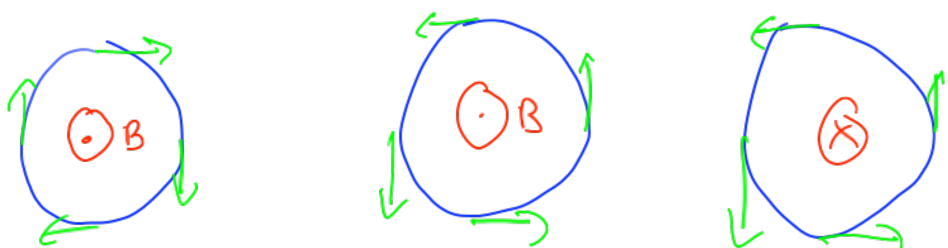
A) 0.2 Tm^2
B) 0.5 Tm^2
C) 1.2 Tm^2
D) 3.0 Tm^2
E) 4.2 Tm^2

$$\Phi_B = \int \vec{B} \cdot \hat{n}\, dA = \int B_2\, dA = B_2 A = 0.2\,T \times 6\,m^2$$
$$= 1.2\,T \cdot m^2$$

Discussion: Faraday's Law

$$\Phi_B = \int \vec{B}\cdot\hat{n}\,dA$$

$$-\frac{d\Phi_B}{dt} = \mathcal{E}mf \qquad \mathcal{E}mf = \oint \vec{E}_{NC}\cdot d\vec{\ell}$$



out, increasing

$\frac{d\vec{B}}{dt}$ ⊙

$-\frac{d\vec{B}}{dt}$ ⊗

out, decreasing

$\frac{d\vec{B}}{dt}$ ⊗

$-\frac{d\vec{B}}{dt}$ ⊙

In, increasing

$\frac{d\vec{B}}{dt}$ ⊗

$-\frac{d\vec{B}}{dt}$ ⊙

$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d}{dt}\left[\int \vec{B}\cdot\hat{n}\,dA\right]$$

Tangible: Table Flux

$B_{\parallel} = 2.0e{-5}\ T$ in N direction

$B_{\perp} = 5.0e{-5}\ T$ down

Φ_B through table? $\int \vec{B} \cdot \hat{n}\, dA = \pi R^2 B_{\perp} = 1.57 \times 10^{-4}\ T \cdot m^2 = \Phi_0$

Consider copper wire $R = 0.5\,\Omega$

Flip over table in 2 seconds

What is I?

$\mathcal{E}mf = -\dfrac{d\Phi_B}{dt} = -\dfrac{(-\Phi_0 - \Phi_0)}{2s} = \dfrac{2\Phi_0}{2s} = 1.57 \times 10^{-4}\ V$

$I = \dfrac{\mathcal{E}mf}{R}$

$= \dfrac{1.57 \times 10^{-4} V}{0.5\,\Omega}$

$= 3.14 \times 10^{-4} A$

Ponderable: Faraday's Law Exercises

Let There Be Light

# of turns

$$B_{sol} = \frac{\mu_0 N I}{L} = \mu_0 n I$$

length

$\hookrightarrow$ $\frac{\text{\# of turns}}{m}$

$$-\left(\frac{0-\Phi_{B_0}}{\Delta t}\right) = \varepsilon_{emf} = \frac{\Phi_{B_0}}{\Delta t}$$