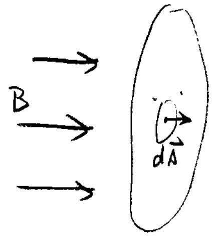
20.1 B-field of 1.2 mT $\perp$ to area of 25 cm^2.

What is B-flux?

$$\Phi_M = \int \vec{B} \cdot d\vec{A}$$



$\vec{B}$ is parallel to $d\vec{A} \Rightarrow \vec{B} \cdot d\vec{A} = B\,dA$

$\Phi_M = \int B\,dA$ but B is constant

$$\Rightarrow \Phi_M = B \int dA = BA = (1.2 \times 10^{-3}\ T)(25\ cm^2)\left(\frac{m}{100\ cm}\right)^2$$

$$\boxed{\begin{aligned} \Phi_M &= 3 \times 10^{-6}\ T \cdot m^2 \\ &= 3.0 \times 10^{-6}\ Wb \end{aligned}}$$

20.3 flux of 6.0 mWb

passes along bar w/cross-sectional area 50 cm^2.

Find flux density.

$$\text{flux density} = \frac{\Phi_M}{A} = \frac{6.0 \times 10^{-3}\ Wb}{50\ \cancel{cm^2}} \times \left(\frac{100\ cm}{m}\right)^2$$

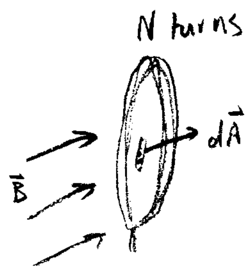
$$\boxed{\text{flux density} = 1.2\ Wb/m^2}$$

Also B is referred to a flux density. (pg. 808)

$$B = \frac{\Phi_M}{A} = \frac{\int \vec{B} \cdot d\vec{A}}{A} = \frac{BA}{A} = B$$

20.17 Flat coil of area A, w/ N turns has a downward B-field fills and surrounds coil.

If $B(t) = B_0 e^{-ct}$, find induced emf in coil.



Induced emf in coil:

$$\mathcal{E} = -N \frac{d\Phi_M}{dt} \qquad (20.3)$$

where $\Phi_M = \int \vec{B} \cdot d\vec{A} = B(t)A$ (since $\vec{B}$ is parallel to $d\vec{A}$)

$$\Phi_M = B_0 e^{-ct} A$$

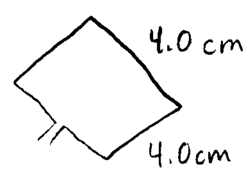
$$\mathcal{E} = -N \frac{d}{dt}\left(B_0 e^{-ct} A\right) = -NB_0 A \frac{d}{dt}\left(e^{-ct}\right)$$

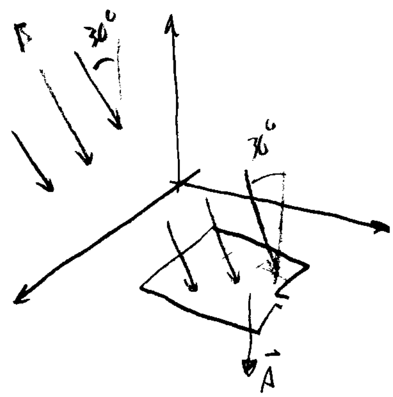
$$= -NB_0 A(-c)e^{-ct} = \boxed{NAB_0 c\, e^{-ct} = \mathcal{E}}$$

20.21 Single loop of wire in a square

B-field downward at 30° from vertical.

Find induced emf as B varies from $0 \to 0.5\ \text{T}$ in 200 ms





$$\mathcal{E} = -\frac{d\Phi_M}{dt}, \quad \Phi_M = \int \vec{B} \cdot d\vec{A} = B(t) A \cos 30^\circ$$

$$\mathcal{E} = -\frac{d\Phi_M}{dt} = -\frac{d}{dt}\left[B(t) A \cos 30^\circ\right]$$

$$= -A\cos 30^\circ \frac{dB(t)}{dt} = -A\cos 30^\circ \frac{\Delta B}{\Delta t}$$

$$= -(0.04\text{m})^2 \cos 30^\circ \left(\frac{0.5\text{T} - 0}{0.2\text{ s}}\right) = \boxed{-3.46\ \text{mV} = \mathcal{E}}$$ counterclockwise (MORE)

20.21 cont'd

More about the direction of current

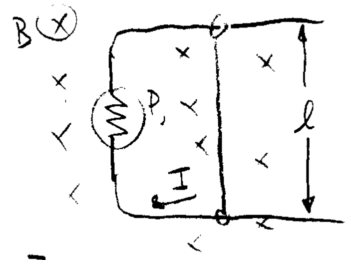
The changing magnetic field induces a current. This current produces a magnetic flux opposite to the original (or given) B-field. The original B-field is downward, so the current must create a B-field upward. By the right-hand rule, the current must be <u>counterclockwise</u> in order to produce an upward B-field.

$\boxed{20.45}$ 5 W lamp draws 200 mA = I

B-field is 0.40 T

Wire moved at $v = 2.00\ m/s$

How long, ℓ, to properly operate lamp?



Lamp needs current I and voltage (emf) given by

$$P = IV \Rightarrow V = \frac{P}{I} = \frac{5\ W}{0.2\ A} = \boxed{25\ V = \mathcal{E}}$$

$\mathcal{E}$ (emf) is created by changing area of loop which changes the magnetic flux:

$$\mathcal{E} = -\frac{d\Phi_M}{dt} \quad \text{but} \quad \Phi_M = \int \vec{B}\cdot d\vec{A} = B\,A(t)$$

since B is constant, A changes with time, and they are both parallel.

$$\mathcal{E} = -\frac{d}{dt} B A(t) = -B\frac{dA(t)}{dt}$$

$\frac{dA(t)}{dt} = ?$ area is length times width

$\frac{dA}{dt}$ is rate of change in length times width:

$$\frac{dA(t)}{dt} = v \times \ell$$

$$\Rightarrow \mathcal{E} = -Bv\ell \Rightarrow \ell = \frac{\mathcal{E}}{Bv} = \frac{25\ V}{(0.4\ T)(2\ m/s)} = \boxed{31.25\ m = \ell}$$

$\boxed{20.71}$ Solenoid w/ $N = 500$ turns

$I = 3.8$ A

produces $\Phi_M = 2.0$ mWb

Compute self-inductance:

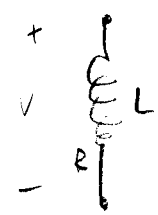
$$L = \frac{N\Phi_M}{I} \qquad (20.8)$$

$$= \frac{500 \times (2.0 \times 10^{-3}\ \text{Wb})}{(3.8\ \text{A})} = \boxed{0.263\ \text{H} = L}$$

$\boxed{20.95}$ 20 V appears across a 10.0 mH coil w/ $R = 5.00\ \Omega$

Determine rate at which current begins to flow. $\frac{dI}{dt}$

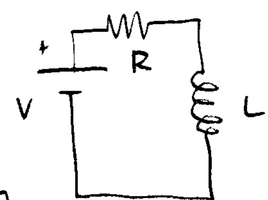
R-L circuit:



$$V = L\frac{dI}{dt} + IR \qquad (20.11)$$

Initially $I = 0$

$$\Rightarrow \quad V = L\frac{dI}{dt}$$



$$\Rightarrow \quad \frac{dI}{dt} = \frac{V}{L} = \frac{20\text{V}}{10 \times 10^{-3}\text{H}} = \boxed{2000\ \text{A/s} = \frac{dI}{dt}}$$

$\boxed{20.107}$ $L = 40.0\,mH$ coil

after a long time $I = 2.0\,A$

How much energy is stored? in inductor

$$PE_M = \frac{1}{2} L I^2 \qquad (20.14)$$

$$= \frac{1}{2}(40 \times 10^{-3})(2.0\,A)^2 = \boxed{0.08\,J = PE_M}$$

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