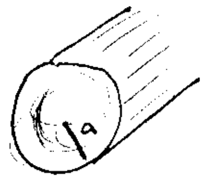
29-43 Large radius wire

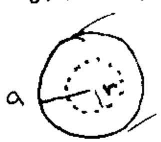
$a = 2\text{ cm} = 0.02\text{ cm}$

Uniformly distributed current

$I = 170$ Amps



Inside the wire



Amperian loop at radius r

$\oint \bar{B} \cdot d\bar{s} = \mu_0 I_{thru}$

only a portion of the total current goes through the loop

$$B \cdot 2\pi r = \mu_0 I \frac{\pi r^2}{\pi a^2}$$

~~B 2π r.~~

At $r = 1\text{ cm} = 0.01\text{ m}$

$$B \cdot 2\cancel{\pi}(0.01) = (4\cancel{\pi}\times10^{-7})\,170\,\frac{\cancel{\pi}(0.01)^2}{\cancel{\pi}(0.02)^2}$$

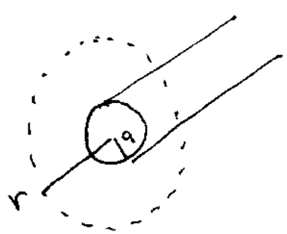
$B = 8.5\times10^{-4}$ Tesla

At $r = 2\text{ cm} = 0.02\text{ m}$

$$B\ 2\cancel{\pi}(0.02) = (4\cancel{\pi}\times10^{-7})\,170\,\frac{\cancel{\pi}(0.\cancel{0}2)^2}{\cancel{\pi}(0.\cancel{0}2)^2}$$

$B = 1.7\times10^{-3}$

Outside the wire at $r = 4\text{ cm} = 0.04\text{ m}$



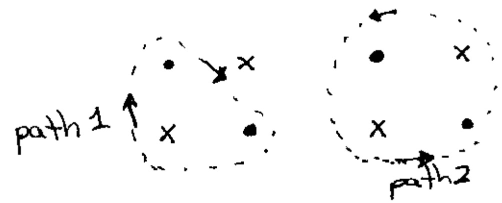
$\oint \bar{B} \cdot d\bar{s} = \mu_0 I_{through}$

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

$B\ 2\cancel{\pi}(0.04) = (4\cancel{\pi}\times10^{-7})\,170$

$B = 8.5\times10^{-4}$ Tesla

29-45



$\oint \bar{B} \cdot d\bar{s} = \mu_0 I_{thru}$

the direction of the loop defines which currents enter as positive or negative

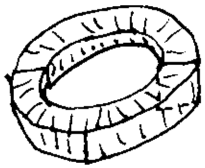
path 2

$$\oint \bar{B} \cdot d\bar{s} = \mu_0 \overset{NW\ \ SW\ \ SE\ \ NE}{(2 + {}^-2 + 2 + {}^-2)} = 0$$

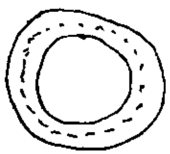
path 1

$$\oint \bar{B} \cdot d\bar{s} = \mu_0 \overset{NW\ \ SE\ \ SW}{({}^-2 + {}^-2 + 2)} = \mu_0(-2)$$

29-49 square toroid ~ square doughnut



inner radius = 15 cm
outer radius = 15+5 = 20 cm
500 turns
$I = 0.8$ Amp



Amperian loop dotted

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{thru}$$
$$B\, 2\pi r = \mu_0 N I$$

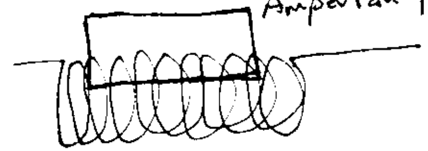
At $r = 0.15$ m

$$B\, 2\pi (0.15) = (4\pi \times 10^{-7})\, 500(0.8)$$
$$B = 5.33 \times 10^{-4} \text{ Tesla}$$

At $r = 0.20$ m

$$B\, 2\pi (0.20) = (4\pi \times 10^{-7})\, 500(0.8)$$
$$B = 4 \times 10^{-4} \text{ Tesla}$$

29-51 Solenoid



Amperian path

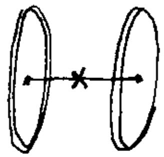
$B \approx 0$ outside
B = const & strong inside

$$\oint B \cdot d\vec{s} = \mu_0 I_{thru}$$
$$B L = \mu_0 N I$$
$$B = \mu_0 \frac{N}{L} I$$

$N = 200$
$L = 0.25$ m
$I = 0.29$ A

$$B = (4\pi \times 10^{-7}) \frac{200}{0.25} (0.29)$$
$$= 2.91 \times 10^{-4} \text{ Tesla}$$

29-56



N = 200 each
R = 25 cm
separation s = R
I = 12.2 mA

The expression for the magnetic field of a single coil on the axis is

$$B = \frac{\mu_0 N I R^2}{2\,(R^2+z^2)^{3/2}}$$

(eqn 29-26)
(and classnotes)

Note that because z^2, then $\pm z$ have same magnitude

The mid-point of both coils, denoted "$*$" is located $z = \pm \frac{1}{2} R$

The total B-field from both coils is then

$$B_{TOT} = 2\left[\frac{\mu_0 N I R^2}{2\,(R^2+z^2)^{3/2}}\right] \text{ with } z = \tfrac{1}{2}R$$

$$= \frac{\mu_0 N I R^2}{\left(\frac{5}{2}R^2\right)^{3/2}}$$

$$= \left(\frac{2}{5}\right)^{3/2} \frac{\mu_0 N I R^2}{R^3}$$

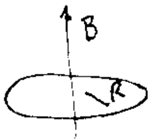
$$= \left(\frac{2}{5}\right)^{3/2} \frac{\mu_0 N I}{R}$$

$$\simeq \left(\frac{2}{5}\right)^{3/2} \frac{(4\pi \times 10^{-7})\, 200\, (12.2\times 10^{-3})}{0.25}$$

$$= 3.1 \times 10^{-6} \text{ Tesla}$$

~~0.32 Volt?~~

30-2



$R = 12\text{ cm} = 0.12\text{ m}$

$B = 0.8\,T$

radius shrinks at $75\text{ cm/s} = 0.75\text{ m/s}$

$\phi = \int \bar{B} \cdot d\bar{A}$

$\phi = BA$

$\phi = B\pi R^2$

$$\text{Induced Emf} = -\frac{d\phi}{dt}$$

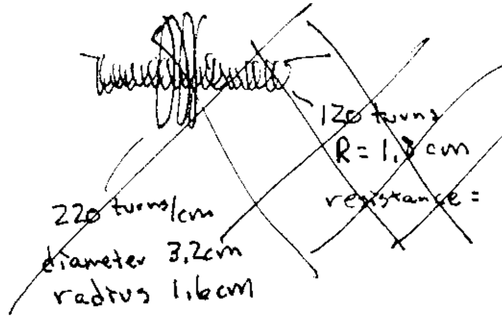
$$= -\frac{d}{dt}(B\pi R^2)$$

$$= \cancel{-} B\pi\, 2R \frac{dR}{dt}$$

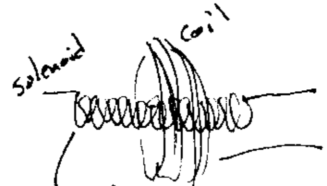
$$= (0.8)\, \pi\, 2\,(0.12)(-0.75\text{ m/s})$$

$$= 0.452 \text{ Volts}$$

30-3



got the coils backwards



120 turns
$R = 1.8$ cm
resistance $5.3\,\Omega$

220 turns/cm
diameter 3.2 cm
radius 1.6 cm

The solenoid current drops from 1.5 A to zero in $\Delta t = 25$ ms

The B-field created by a solenoid is

$$B_1 = \mu_0 \frac{N_1}{L_1} I_1$$

The flux through the coil is

$$\phi = \int \bar{B} \cdot d\bar{A} = B_1 (A_2 N_2) = \mu_0 \frac{N_1}{L_1} I_1 \cdot A_2 N_2$$

The induced Emf is $= -\frac{d\phi}{dt}$

$$\text{Ind Emf} = -\frac{d}{dt}\left[\mu_0 \frac{N_1}{L_1} I_1 A_2 N_2\right]$$

$$= \cancel{-}\, \mu_0 \frac{N_1}{L_1} \left(\frac{dI_1}{dt}\right) A_2 N_2$$

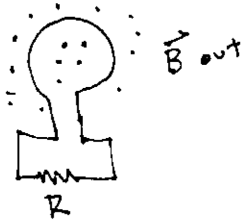
$$= -(4\pi \times 10^{-7})(220 \times 10^2)\left[\frac{-1.5}{25 \times 10^{-3}}\right] \pi (0.018)^2 \cdot 120$$

$$= 0.202 \text{ Volts}$$

Then the current will be

$$\frac{0.202 \text{ Volts}}{5.3\,\Omega} = 3.81 \times 10^{-2} \text{ Amp}$$

30-7



$\phi = 6t^2 + 7t$ in milliWebers

Induced Emf $= -\frac{d\phi}{dt} = -(12t+7)$ milliVolts

at $t = 2$ seconds

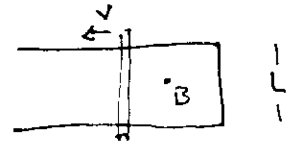
$= -(12(2)+7)$

$= -31$ milliVolts

The direction of the current is in a direction so as to oppose the increase in magnetic flux

$\therefore$ the "Induced B-field" is $\otimes$ down and the induced current is then CW around the loop

30-29



$B = 0.350$ T

$L = 0.25$ m

$v = 55$ cm/s $= 0.55$ m/s

Induced Emf for rod on rails

$\phi = \int \vec{B} \cdot d\vec{A} = BA = BLx$

Induced Emf $= -\frac{d\phi}{dt} = -BL\frac{dx}{dt} = -BLv$

$= -(0.350)(0.25)(0.55 \text{ m/s})$

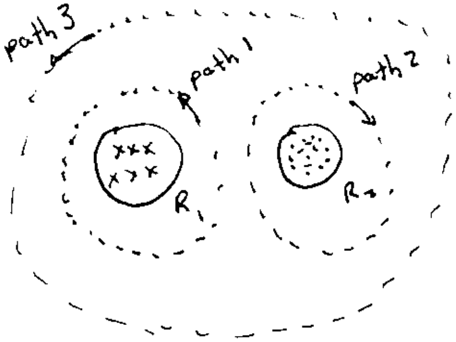
$= -4.81 \times 10^{-2}$ Volts

Induced Current $\frac{\text{Induced Emf}}{\text{resistance}} = \frac{4.81 \times 10^{-2}}{18\,\Omega} = 2.67 \times 10^{-3}$ Amp

Power $= IV$

$= (2.67 \times 10^{-3})(4.81 \times 10^{-2}) = 1.29 \times 10^{-4}$ watts

30-36



$r_1 = 20\text{ cm}$ $\quad B_1 = 50\text{ mT}$

$r_2 = 30\text{ cm}$ $\quad B_2 = 75\text{ mT}$

both $\frac{dB_1}{dt} = \frac{dB_2}{dt} = 8.5\text{ mT/s}$ decreasing

$$\oint \bar{E}\cdot d\bar{s} = -\frac{d\phi_B}{dt} \qquad \phi_B = \int \bar{B}\, d\bar{A} = \bar{B}\cdot\bar{A}$$

$$= -\frac{d\phi_B}{dt}$$

$$= -\frac{d}{dt}(\bar{B}\cdot\bar{A})$$

$$= -\frac{d\bar{B}}{dt}\cdot\bar{A}$$

path 1 $\quad \times \bar{B}_1 \quad \bullet \frac{d\bar{B}_1}{dt}$

$$\oint \bar{E}\cdot d\bar{s} = -(8.5\times10^{-3})\,\pi\,(0.20)^2$$

$$= -1.07\times10^{-3}\text{ Volts}$$

path 2 $\quad \bullet B_2 \quad \times \frac{d\bar{B}_2}{dt}$

$$\oint \bar{E}\cdot d\bar{s} = -(8.5\times10^{-3})\,\pi\,(0.30)^2$$

$$= -2.40\times10^{-3}\text{ Volts}$$

path 3

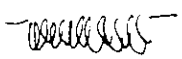
Is the sum of the effects above (actually the difference

$\cancel{= 2.47\times10^{-3}\text{ Volts}}$

$$(-1.07\times10^{-3}) - (-2.40\times10^{-3}) = 1.33\times10^{-3}\text{ Volts}$$

the sense is opposite because of direction

30-37



dia = 12cm
radius = 6 cm
$i =$
$B = 30\,mT$

when i degreases, B ~~increases~~ decrease at 6.5 mT/s

a) at 2.2 cm from axis

$$\int \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt} B \cdot A$$

6 cm

The amperian loop only encloses a portion of the cross sectional area of the solenoid

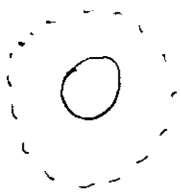
same as amperian loop

$$E\, 2\pi r = -\frac{dB}{dt}\, \pi r^2$$

$$E \cdot 2\pi(0.022) = -\left(-6.5\times10^{-3}\,\tfrac{T}{s}\right)\pi(0.022)^2$$

$$E = 7.15\times10^{-5}\ V/m$$

b) at 8.2 cm from axis



amperian loop

solenoid radius

$$E\, 2\pi r = -\frac{dB}{dt}\,\pi r^2$$

$$E\, 2\pi(0.082) = -\left(-6.5\times10^{-3}\,\tfrac{T}{s}\right)\pi(0.06)^2$$

$$E = 1.43\times10^{-4}\ V/m$$

30-40 Inductance $L = 8\,mH$

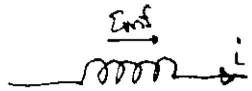
400 turns $I = 5\,mA$

$$N\Phi_B = LI$$

$$400\,\Phi_B = (8\times10^{-3})(5\times10^{-3})$$

$$\Phi_B = 1\times10^{-7}\ \text{Weber}$$

30-45



a) The current would be decreasing because the Emf is in a direction so as to maintain the existing current.

b) Induced Emf = 17 V

$$\frac{dI}{dt} = -25 \text{ kA/s}$$

$$\text{Induced Emf} = -L\frac{dI}{dt}$$

$$17 = -L\left(-25\times10^{3}\text{ A/s}\right)$$

$$L = 6.8\times10^{-3}$$