CH20

1) $\Phi_B = BA\cos\theta$

$\theta = 0^\circ$ (angle between B and the <u>normal</u> of the surface)

$A = \pi r^2 \quad r = 0.25\,m$

$B = 0.30\,T$

$\Phi_B = 0.059\,T \cdot m^2$

2a) $\Phi_B = BA\cos\theta$

$\theta = 0^\circ$

$A = 20\,cm^2 = 0.00200\,m^2$

$B = 5.00 \cdot 10^{-5}\,T$

$\Phi_B = 1.00 \cdot 10^{-7}\,T \cdot m^2$

b) $\Phi_B = BA\cos\theta$

$\theta = 30^\circ$

$\Phi_B = 8.66 \cdot 10^{-8}\,T \cdot m^2$

c) $\theta = 90^\circ$

$\cos 90^\circ = 0$ hence,

$\Phi_B = 0\,T \cdot m^2$

3) $\Phi_B = BA\cos\theta$

$\theta = 50^\circ$

$A = 2 \times 2 = 4\,m^2$

$B = 0.3\,T$

$\Phi_B = 0.771\,T \cdot m^2$

6) $\Phi = BA\cos\theta$

$A = \pi \cdot (0.02)^2 = 0.00126\, m^2$

$\theta = 0^\circ \Rightarrow \cos\theta = 1$

$B = \mu_0 n I = \mu_0 NI/\ell$

$N = 250$

$\ell = 0.2 m$

$I = 15 A$

$B = 0.0236 T$

$\Phi_B = 2.97 \cdot 10^{-5} T.m^2$

8) $\mathcal{E} = -N \frac{\Delta\phi_B}{\Delta t}$

$N = 1$

$\Phi_B = BA\cos\theta$

$\theta = 0$

$B = 1.5 T$

$A = \pi \cdot (1.6 \cdot 10^{-3})^2 = 8.04 \cdot 10^{-6} m^2$

$\Delta t = 0.120$ sec

$\Phi_B = 1.21 \cdot 10^{-5} Tm^2$

because initially B=0 thus $\Phi_{Bi} = 0$.

$\Delta\Phi_B = \Phi_{Bf} - \Phi_{Bi} = 1.21 \cdot 10^{-5} T \cdot m^2 - 0$

$\mathcal{E} = -1.01 \cdot 10^{-4} V$

10) $\Phi_B = BA\cos\theta$

$\theta = 0$

$A = \pi (0.12)^2 = 0.0452 m^2$

$\underbrace{B = 0.15T}$

$\Phi_B = 0.00678\, T \cdot m^2$

$\Phi_{Bf} = 0$

since $A=0$

and therefore

$\Phi_{Bf} = 0$

$\Delta\Phi_B = 0 - 0.00678\, T.m^2$

$= -0.00678\, Tm^2$

$\mathcal{E} = -N \frac{\Delta\Phi_B}{\Delta t}$

$\Delta t = 0.2$ sec

$N = 1$

$\mathcal{E} = 0.0339 V$

13) First calculate the induced voltage/Emf. using Ohm's law.

$$\left.\begin{array}{l} V = I \cdot R \\ I = 0.1A \\ R = 8\Omega \end{array}\right\} V = 0.8V$$ this is equal to the induced Emf.

$$\mathcal{E} = -N \frac{\Delta\Phi_B}{\Delta t}$$

$$\mathcal{E} = 0.8V$$

now we are looking for the change in B over time i.e

$\frac{\Delta B}{\Delta t}$ since A and θ don't change, we can rewrite $\frac{\Delta \Phi_B}{\Delta t}$ as:

$A \cdot \cos\theta \frac{\Delta B}{\Delta t}$ Hence, $\mathcal{E} = -NA\cos\theta \frac{\Delta B}{\Delta t}$

$$\left.\begin{array}{l} N = 75 \\ A = 5 \times 8cm = 0.0040m^2 \\ \theta = 0^\circ \end{array}\right\} \frac{\Delta B}{\Delta t} = \frac{-\mathcal{E}}{NA\cos\theta} = -2.7 T/s.$$

The negative just tells you about the direction, don't worry about it, just use Lenz' law.

14 a) $$\left.\begin{array}{l} B = \mu_0 N I / \ell \\ N = 100 \\ \ell = 20cm \\ I = 3A \end{array}\right\} B = 1.885 \cdot 10^{-5} T \quad \left.\begin{array}{l} \Phi_B = BA\cos\theta \\ \theta = 0 \\ A = 1 \cdot 10^{-4} m^2 \end{array}\right\} \Phi_B = 1.89 \cdot 10^{-7} T \cdot m^2$$

b) $$\left.\begin{array}{l} \mathcal{E} = -N \Delta\Phi / \Delta t \\ \Phi_{Bi} = 1.89 \cdot 10^{-7} T \cdot m^2 \\ \Phi_{Bf} = 0 \\ N = 1 \\ \Delta t = 3 \text{ sec} \end{array}\right\} \mathcal{E} = -6.3 \cdot 10^{-8} V$$

17) First lets calculate the change in flux through the loop.

$\Delta\Phi_B = \Phi_{Bf} - \Phi_{Bi}$ note in this case B and θ are constant

therefore $\Delta\phi_B = B \cdot \cos\theta \cdot \Delta A$

$\left.\begin{array}{l} \Delta A = 0.0039\, m^2 \\ B = 5 \cdot 10^{-5}\, T \\ \underline{\theta = 62°}\,!! \end{array}\right\}$ $\Delta\phi_B = 9.15 \cdot 10^{-8}\, T \cdot m^2$

$\left.\begin{array}{l} \mathcal{E} = -N\, \Delta\Phi_B / \Delta t \\ N = 200 \\ \Delta t = 1.8s \end{array}\right\}$ $\mathcal{E} = 1.02 \cdot 10^{-5}\, V$

52) Find the induced Emf

$\left.\begin{array}{l} \mathcal{E} = -N\, \Delta\Phi_B / \Delta t \\ N = 10 \\ \Delta\Phi_B = \underbrace{\Delta\Phi_{Bf}}_{0} - \Delta\Phi_{Bi} = -BA\cos\theta \end{array}\right\}$ $\mathcal{E} = 0.0063\, V$

$\left.\begin{array}{l} \theta = 0 \\ B = 0.1T \\ A = \pi(0.02)^2 = 0.00126\, m^2 \end{array}\right\}$ $\Delta\Phi_B = 1.26 \cdot 10^{-4}\, T \cdot m^2$

$I = V/R$ $R = 2\,\Omega$ $I = 0.00315\,A = 3.15\,mA$

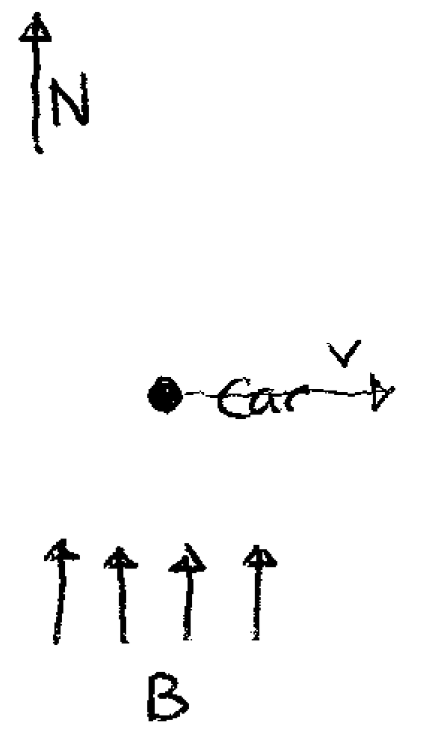
The meter should be sensitive enough to see this current

18) $\mathcal{E} = Blv$ and $\mathcal{E} = IR$ Hence

$I = Blv/R \Rightarrow v = IR/Bl$

$$\left.\begin{array}{l} B = 2.5T \\ l = 1.20m \\ R = 6\Omega \\ I = 0.5A \end{array}\right\} v = 1 m/s$$

21a)

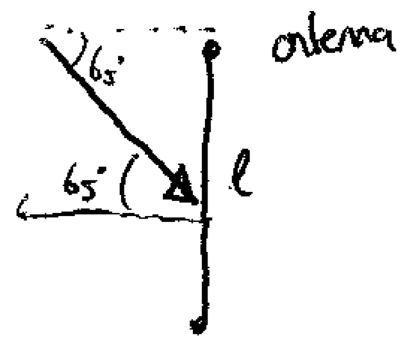


The car would need to move perpendicular to the field i.e. in the east or westward direction

Since the top of the antenna is positive, the car needs to move eastward (use right-hand rule)

(think about this !!)

b) $\mathcal{E} = Blv$ Note: B is the magnetic field perpendicular to the motion!



$$\left.\begin{array}{l} B_{\perp} = B\cos 65° \\ B = 5 \cdot 10^{-5} T \end{array}\right\} = 2.11 \cdot 10^{-5} T$$

$\mathcal{E} = 2.11 \cdot 10^{-5} \cdot 1.2m \cdot \underbrace{65\ km/hr}$

$65\ km/hr = 65000\ m/hr = 65000\ m/3600\ sec = 18.1\ m/s$

$\mathcal{E} = 4.58 \cdot 10^{-4} V$

23a) Use Lenz' Law.

moving to the left will decrease the flux in the solenoid

A current will be induced to counter this loss:

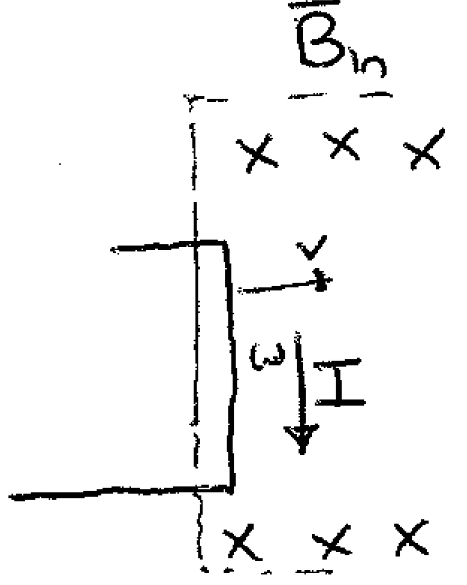
this by the right hand rule will give a current to the right

b) moving to the right decreases the flux in the solenoid.

the current will therefore point in the direction to decrease

the flux. right-hand rule will give a current to the left in the resistor.

25a) when it just enters the B-field:



$F = BINw\sin\theta$ $\theta = 90°$ Nw length of wire

$F = BINw$

generated by change in flux

$I = \mathcal{E}/R$

$\mathcal{E} = BNwv$

Hence

$F = N^2B^2w^2v/R$ (Nw) is the length of the wire inside the B-field

to the left.

b) The flux is zero inside the B-field Hence $\mathcal{E}_{induced} = 0 \Rightarrow F = 0$.

c) A similar picture as a) will give a force in the same direction

when the loop leaves (either way Lenz's law prevents the loop from moving.

$F = N^2B^2w^2v/R$ to the left

29 a). When the switch is closed, current flow clockwise in the ~~left~~ right circuit

- this will create a ~~...~~ B-field to the left
- Lenz law will try to cancel this B-field, Hence a current Clockwise in the left circuit will create a B-field in the Opposite direction. ~~...~~ the current will go to the left in the resistor

b) - The current will increase in the right circuit $\Rightarrow$ B will get stronger
- The current will go to the left in the resistor to counter this change

c) A decrease in B $\Rightarrow$ the current will go to the right to cancel this.

d) Again a decrease in B $\Rightarrow$ the current will go to the right.

6 a) $\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$

$\Delta t = 5\cdot10^{-2}s$

$\Delta\Phi_B = BA\cos\theta = (25\cdot10^{-3}T)(\pi\cdot(0.01)^2 - 0)\cdot 1 = 7.85\cdot10^{-6}T.m^2$

$N = 1$

$\mathcal{E} = 1.57\cdot10^{-4}V$ is the induced voltage. By Lenz' law the current induced in the wire will create a B-field into the page (right hand rule gives ~~...~~ clockwise direction) Hence, B is positive, A is negative

b) $\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$

$\Delta t = 5\cdot10^{-2}s$ $\quad$ $\Delta\Phi_B = \Delta BA\cos\theta = \pi\cdot(0.01)^2\cdot(100\cdot10^{-3}T - 25\cdot10^{-3}T) = 2.36\cdot10^{-5}T\cdot m^2$

$N = 1$

$\mathcal{E} = 5.89\cdot10^{-3}V$ is the induced voltage. A current in the counter clockwise direction will be created, Hence A is ~~neg~~ positive and B is negative

30) $\mathcal{E} = NAB\omega \sin\omega t$ $\quad\quad$ $\mathcal{E}_{max} = NAB\omega$ $\quad$ (i.e. when $\sin\omega t = 1$)

$N = 100$ turns

$A = 0.04\,m^2$

$B = 2 \cdot 10^{-5}\,T$

$\omega = 2\pi f = 2\pi \cdot 25 = 157\,rad/sec$

$f = rot/sec = 1500\,rot/60\,sec = 25$

$\mathcal{E}_{max} = 1.26 \cdot 10^{-2}\,V$

33a) $\mathcal{E}_{max} = NAB\omega$

since B is perpendicular to the axis, $B = 5.5 \cdot 10^{-5}\,T$

$A = \pi\left(\frac{0.1}{2}\right)\left(\frac{0.04}{2}\right) = 3.14 \cdot 10^{-3}\,m^2$

$N = 100$ turns

$\omega = 2\pi f = 10.5\,rad/sec$

$f = 100\,rot/60\,sec = 1.67\,rad/sec$

$1.81 \cdot 10^{-5}\,V = \mathcal{E}_{max}$

b) Since B is parallel to the axis, the flux is 0 through the surface i.e. $\mathcal{E}_{max} = 0\,V$.

34a) $\mathcal{E}_{max} = NAB\omega$

$N = 1000$ turns

$A = 0.1\,m^2$

$B = 0.2\,T$

$\omega = 2\pi f = 2\pi \cdot 60 = 377\,rad/sec$

$\mathcal{E}_{max} = 7540\,V$

b) $\mathcal{E}_{max}$ occurs when the change in flux is greatest, this is ~~from~~ when the plane of the coil is parallel to the magnetic field

39a) for a solenoid: $L = \mu_0 N^2 A / \ell$

$\mu_0 = 4 \cdot \pi \cdot 10^{-7}$
N = 400 turns
$A = \pi \cdot (0.025)^2 = 0.00196\,m^2$
$\ell = 0.2m$

$\Big\}\ L = 1.97 \cdot 10^{-3} H$

b) $L = -\mathcal{E} / \Delta I/\Delta t$

$\Delta I/\Delta t$ = rate of change of current
$L = 1.97 \cdot 10^{-3} H$
$\mathcal{E} = 75 \cdot 10^{-3} V$

$\Big\}\ \frac{\Delta I}{\Delta t} = \frac{-75 \cdot 10^{-3} V}{1.97 \cdot 10^{-3} H} = 38.1\, A/s$

42a) $\tau = L/R$ for inductor $\tau = RC$ for capacitor if these are equal:

$L/R = RC \Rightarrow R^2 = L/C \quad R = \sqrt{L/C}$

$L = 3H$
$C = 3 \cdot 10^{-6} \mu F$

$\Big\}\ R = 1000\,\Omega$

b) $\tau = L/R$
$L = 3H$
$R = 1000\Omega$

$\Big\}\ \tau = 3 \cdot 10^{-3} s$

or

$\tau = RC$
$R = 1000\Omega$
$C = 3 \cdot 10^{-3} \mu F$

$\Big\}\ \tau = 3 \cdot 10^{-3} s$

Good, these are the same.

46 a) $\tau = L/R$

$L = 8\cdot10^{-3}H$

$R = 4\Omega$

$\tau = 2.00\cdot10^{-3}\,sec$

b) $I = \mathcal{E}/R\,(1 - e^{-Rt/L})$ (eq from below 20.14)

$\mathcal{E} = 6V$

$R = 4\Omega$

$L/R = 2\cdot10^{-3}\,sec$

$I = \frac{6V}{4\Omega}\left(1 - e^{-t/2\cdot10^{-3}\,sec}\right)$

$t = 2.50\cdot10^{-4}\,sec \Rightarrow I = 0.176A$

~~Thus~~

c) When t gets large $e^{-t/\tau}$ gets small enough to ignore (try t=100sec and you will see what I mean). Hence

$I = \mathcal{E}/R$ = final current $I = 1.5A$

d) $I = I_f(1 - e^{-t/\tau})$

$\frac{I}{I_f} = (1 - e^{-t/\tau})$

$\frac{I}{I_f} = 0.8 = 1 - e^{-t/\tau}$ $\quad e^{-t/\tau} = 0.2$ $\quad \tau = 2\cdot10^{-3}\,sec \Rightarrow t/\tau = -\ln(0.2)$

$t = 3.22\cdot10^{-3}$ sec which is between τ and 2τ as it should be.

Note: these problems are almost identical to the capacitor/resistor circuits. except $\tau = L/R$ not $\tau = RC$. and it is the current we have in the equation, not the charge.!!

49a) The maximum current is $I = \mathcal{E}/R = 24/8 = 3A$.

$PE_L = \frac{1}{2} \cdot L \cdot I^2$
$L = 4H$
$I = 3A$
$\Big\}$ $PE_L = 18 J$

b) The current after 1 time constant is 63.2% the final current

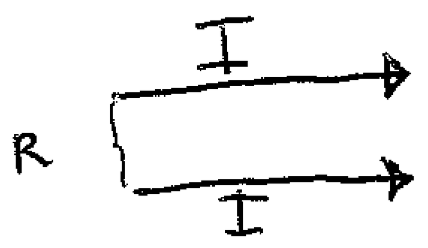
Hence $I = 0.632 \cdot 3A = 1.896A$

$PE_L = \frac{1}{2} L \cdot I^2$
$L = 4H$
$I = 1.896A$
$\Big\}$ $PE_L = 7.2 J$

56a) $PE = \frac{1}{2} L . I^2$
$L = 50H$
$I = 50 \cdot 10^3 A$
$\Big\}$ $PE_L = 6.25 \cdot 10^{10} J$

b) for a straight wire $B = \mu_0 I / 2\pi R$

$I = 50 \cdot 10^3 A$
$R = 0.25m$
$\Big\}$ $B = 0.04T$



$F = BIl$
$I = 50 \cdot 10^3 A$
$\Big\}$ $\frac{F}{l} = BI = 2000 N/m$.