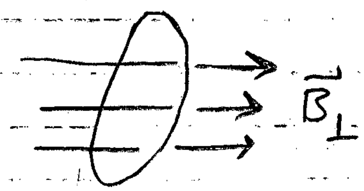
Physics 1B - CHAP 20 Solutions (1)

Easy

1 $B_\perp = 0.3\,T$
$r = .25\,m$



Flux = amount of magnetic field going through the surface
$= BA\cos\theta$; $A = \pi r^2$; $\theta = 0°$ because the B field is $\perp$ to the surface.

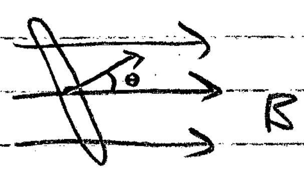
Flux $= (.3T)\,\pi\,(.25m)^2 \cos 0° = \boxed{.059\,Tm^2}$

2 $B = 5\times10^{-5}\,T$
$A = 20\,cm^2 = .002\,m^2$

(a) They are perpendicular $(\theta = 0°)$

Flux $= BA\cos 0° = \boxed{1\times10^{-7}\,Tm^2}$

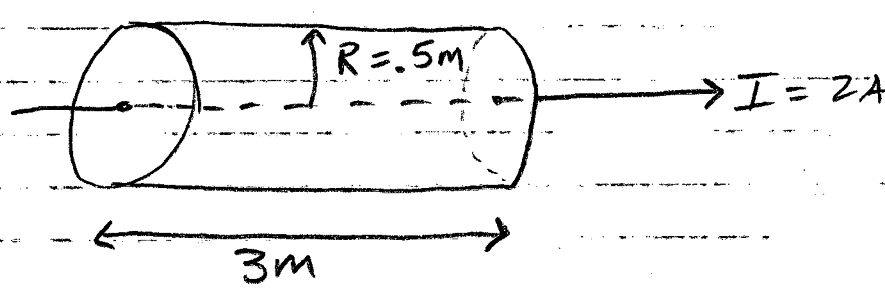
(b) $\theta = 30°$

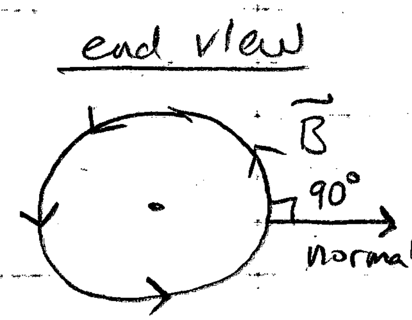


Flux $= \Phi_B = BA\cos 30° = \boxed{.866\times10^{-7}\,Tm^2}$

(c) $\theta = 90° \rightarrow$ Flux $= BA\cos 90° = \boxed{0;\ \text{No flux}}$

4





$\Phi_B = BA\cos\theta$, but $\theta = 90°$ because the B field curls around and the normal to the surface is radially outward. $\boxed{\text{Flux} = 0}$

Easy

10 Your loop starts with $A_i = \pi r^2 = \pi(.12m)^2$

When you stretch it flat the final area $= A_f = 0$

$\vec{B}$ = constant = 0.15T ; θ = const = 0° ; Δt = .2s

Induced EMF $= \mathcal{E} = -N \frac{d\Phi_B}{dt} = \frac{-N B \Delta A \cos 0°}{\Delta t}$

$$\mathcal{E} = -(1)(.15T)\left[\pi(.12m)^2 - 0\right]\cos 0° / 0.2s$$

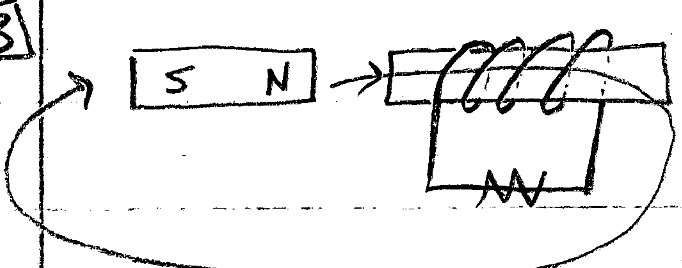
$$\boxed{\mathcal{E} = .034V}$$

11 Now Area = constant $= \pi(.3m)^2$; $\theta = 0°$; $\Delta t = 1.5s$
but $\vec{B}$ is changing from .3T in one direction to .2T in the opposite direction; so $\Delta B = .5T$

$$\mathcal{E} = -N\frac{d\Phi_B}{\Delta t} = -(1)(.5T)\,\pi(.3m)^2(\cos 0°)/1.5s$$

$$\boxed{\mathcal{E} = .094V}$$

23



First draw field lines from the magnet
This tells us the flux is to the right

(a) If the magnet moves left, less flux is going to the right, so the induced current will try to restore more flux to the

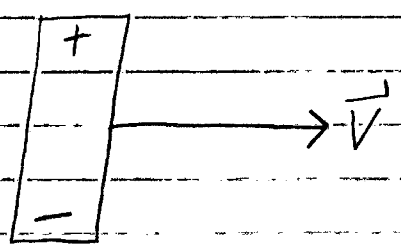
Easy

23-cont

right. The current which will give the needed flux to the right is going through the resistor to the right.

(1b) ~~If~~ magnet moves right, the flux through the coil is increasing, so the induced current will try to resist the change and cause an induced flux to the left. The current to the left will cause this.

27



Since (+) charges went to the top of the bar, that is the direction of the force in the equation $F = qVB\sin\theta$.

F is up
V is right
find B

use RHR #1 to find: $\boxed{B \text{ into the page}}$

31

$B = 1 \times 10^{-3}\ T$

$f = 60\ Hz \rightarrow \omega = 2\pi(60) = 120\pi$

$d = 8\ \mu m$

$\mathcal{E}_{max} = ?$

$$\mathcal{E}_{max} = NAB\omega = (1)\left[\pi(4\ \mu m)^2\right](1\ mT)(120\pi)$$

$$\boxed{\mathcal{E}_{max} = 1.9 \times 10^{-11}\ V}$$

Easy

37

$L = 3.0\,mH$
$I_i = 0.2\,A$
$I_f = 1.5\,A$
$\Delta t = 0.2\,s$

$$|\mathcal{E}| = L\frac{dI}{dt} = \frac{3mH\,(1.5A - .2A)}{0.2\,s}$$

$$\boxed{|\mathcal{E}| = 19.5\,mV}$$

42

$L = 3\,H$ (RL)

$C = 3\,\mu F$ (RC)

Both circuits (RL & RC) have the same time constant and the same resistance R

ⓐ find R $\quad \tau_{RC} = \tau_{RL} \rightarrow RC = \frac{L}{R} \rightarrow R = \sqrt{\frac{L}{C}} = 1000$

$$\boxed{R = 1000\,\Omega}$$

ⓑ find τ

$$\tau = RC = (1000\,\Omega)(3\,\mu F)$$

$$\boxed{\tau = .003\,s}$$

47

$L = 70\,mH$
$I = 2A$
energy stored $= U = \frac{1}{2}LI^2 = 140\,mJ = \boxed{.14\,J}$

Medium

13 coil

$A = (.05\,m)(.08\,m)$

$N = 75$

$R = 8.0\,\Omega$

$I = .1\,A$

$\frac{dB}{dt} = ?$

We can combine the induced flux equation and ohm's law as follows

$V = IR$

$V = -N\frac{d\Phi}{dt} = -N\frac{dB}{dt}A$

so $IR = -NA\frac{dB}{dt}$

so $\frac{dB}{dt} = \frac{IR}{NA}$ (minus sign just tells the direction)

$$\frac{dB}{dt} = \frac{(.1\,A)(8\,\Omega)}{(75)(.004\,m^2)} \rightarrow \boxed{\frac{dB}{dt} = 2.67\,\frac{T}{s}}$$

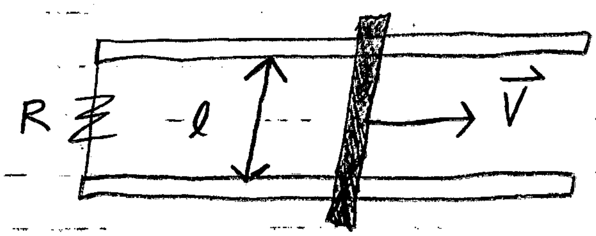
18 $R = 6\,\Omega$

$\ell = 1.2\,m$

$B = 2.5\,T$ into page

$I = .5\,A$

$v = ?$ velocity



When you move the bar the area will change, so the flux will change, so there will be an induced voltage and therefore an induced current.

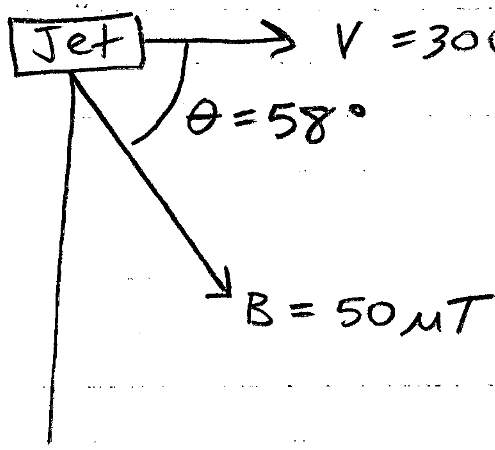
$V = IR$ and $V_{ind} = -N\frac{d\Phi_B}{dt} = \frac{-NB\Delta A}{\Delta t} = NB\ell V$

$IR = NB\ell V$

$$V = \frac{IR}{NB\ell} = \frac{(.5\,A)(6\,\Omega)}{(2.5\,T)(1.2\,m)} = \boxed{1\,m/s = V}$$

Medium

19



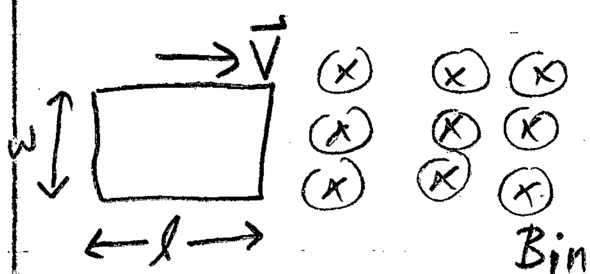
(wings length 60 m)

$|\mathcal{E}| = B_\perp l V$ note that $B_\perp = B\sin\theta$

$|\mathcal{E}| = B l V \sin\theta$

$\boxed{|\mathcal{E}| = .76\ V}$

25



This is a 2-part problem
1) find the induced current
2) find the force acting on the induced current

(a)

1) The voltage around the loop is caused by the motion into the loop and an increasing flux through the loop. $\Delta V = NBlV$ but in this case "l" is actually "w" because of how it is drawn.
Combining with Ohm's law we have
$V = IR = NBwV$ so $I = \frac{NBwV}{R}$

2) We use Lenz's law to get the direction: when loop moves into field, flux is increasing into the page, so induced flux opposes that and points out of the page.
A counter clockwise current will provide the required flux.

Thus: $I = \frac{NBwV}{R}$ counterclockwise

Medium

25-cont

2) Now we must find the force on the loop. Notice only the right edge is in the B field, so that is the only part that will feel a force. $F = NI\ell B \sin\theta$ where $\theta = 90°$ and once again "ℓ" is actually "w" for this problem.

Thus $F = NIwB = N\left(\frac{NBwv}{R}\right)wB = \boxed{\frac{N^2B^2w^2v}{R}}$

Using the RHR #1 we find the force is → $\boxed{\text{Left}}$ because I points up & B points into page.

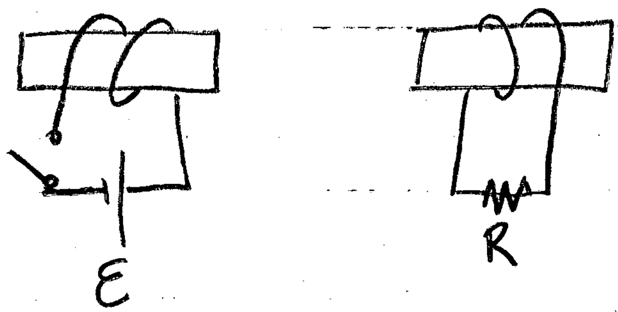
(c) Everything is the same except the flux is now decreasing so the current flows the opposite direction, clockwise.

However, now the left side of the loop is in the field, so using the right hand rule we again find the force to the $\boxed{\text{Left}}$ with the same magnitude.

(b) Since the flux is constant there is no induced EMF, and thus no current, and thus no force. $\boxed{F=0}$

Medium

28



(a) When the switch is closed, current flows through the left coil and causes B field increasing to the right. Thus, the left coil will induce a current to oppose this increasing B flux by causing flux to the left. Current from left → Right through the resistor will give flux to the left.

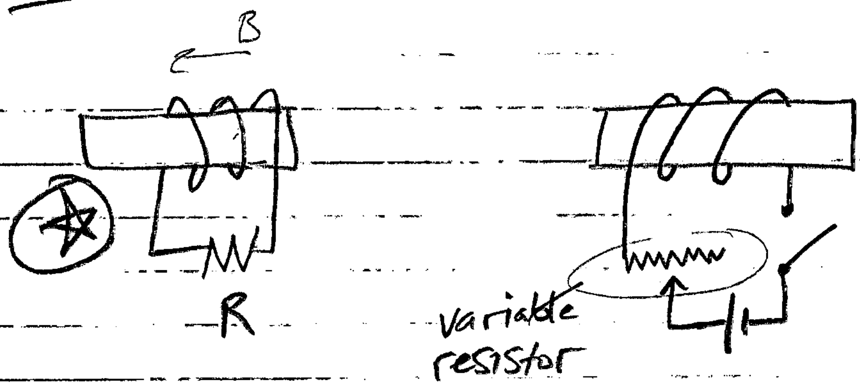
(b) When the switch remains closed, there is still a $\vec{B}$ field to the right, but it is constant, so there is no induced current

(c) When switch is opened, the B field still points right but is now decreasing, so the induced B field points the same way. Current Right to left will induce this correct B field.

Note: You must look at the change in the B field from before to after, not the actual direction of the B field.

Medium

29



(a) closing switch induces current and B field increasing to the left. To oppose this, current flows right to left in resistor R

(b) variable resitance decreased causes an increase in current by ohm's law ($V=IR$) and thus an increase in B. Once again, to oppose this increase to the left, the induced B field points right, so current flows right to left

(c) When you move the ☆ circuit to the left, the flux to the left will decrease because B is decreasing as you move farther away from the source. So we need more flux to the left, and the current will flow left to right through the resistor.

(d) switch is opened means the flux pointing to the left in ☆ is decreasing. To oppose this, current will flow left to right again.

Medium

34 $A = 0.10\,m^2$
$f = 60$ rev/s $\rightarrow \omega = 2\pi f = 120\pi$ rad/sec
$B = 0.20$ T

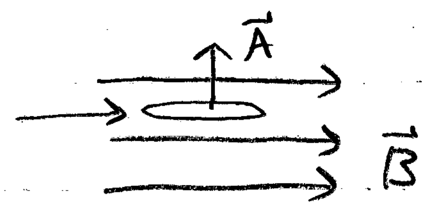
ⓐ $N = 1000$, Find $\mathcal{E}_{max}$

$$\mathcal{E}_{max} = \max[NBA\omega \sin\omega t] = NBA\omega$$

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

ⓑ How is the coil oriented when $\mathcal{E} = \mathcal{E}_{max}$?
note $\omega t = \theta$ so $\sin(\omega t) = \sin(\theta)$ and this is max for $\theta = 90°$; θ is the angle between the B field and the normal of the loop; thus the plane of the loop should be parallel to the B field

max $\mathcal{E}$ when: loop $\longrightarrow$



39 $r = 2.5\,cm = 0.025\,m$
$N = 400$
$\ell = 0.2\,m$
– solenoid

ⓐ find Inductance $L_{solenoid} = \mu_0 N^2 \dfrac{A}{\ell} = \dfrac{\mu_0 N^2 \pi r^2}{\ell}$

$$L = .00197 = \boxed{1.97\,mH = L}$$

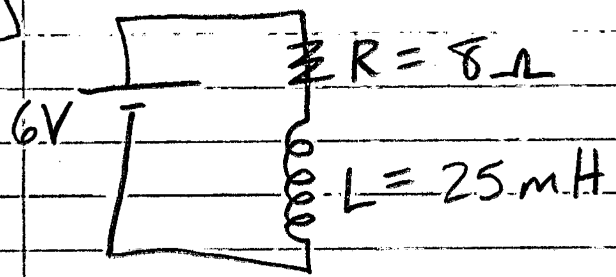
ⓑ If $\mathcal{E} = 75\,mV$, find dI/dt; rate of current change.

$$\mathcal{E} = -L\frac{dI}{dt} \rightarrow \frac{dI}{dt} = -\frac{\mathcal{E}}{L} = \frac{75\,mV}{1.97\,mH}$$

$$\boxed{\frac{dI}{dt} = 38.1\,A/s}$$

Medium

44



ⓐ ΔV_R at $t=0$

Since the current starts at zero, $\Delta V_R = IR$

$\boxed{\Delta V_R = 0}$

ⓑ ΔV_R at $t=\tau$

We need the current after 1 time constant

$I(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right)$ at $t=\tau$ becomes:

$I(t=\tau) = \frac{6V}{8\,\Omega}\left(1 - e^{-1}\right) = .474\ A$; $\Delta V_R = IR$

$\boxed{\Delta V_R = 3.79V}$

ⓒ ΔV_L at $t=0$

Since the total ΔV of R and L must equal $\Delta V_{Battery}$, we have $6V = \Delta V_R + \Delta V_L$

at $t=0$ $\quad 6V = 0 + \Delta V_L$ so $\boxed{\Delta V_L = 6V}$

ⓓ at $t=\tau$ $\quad 6V = 3.79V + \Delta V_L$ so $\boxed{\Delta V_L = 2.21V}$

48

$N = 300$
$r = .05m$
$l = .2m$

ⓐ $L = \frac{\mu_0 N^2 A}{l} = \frac{\mu_0 N^2 \pi r^2}{l}$

$\boxed{L = 4.4mH}$

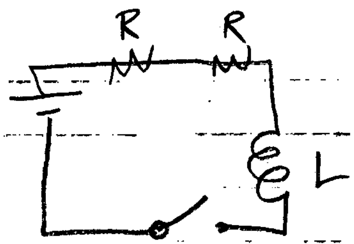
ⓑ $I = 0.5A$, find U $\quad U = \frac{1}{2}LI^2$

$\boxed{U = 5.55 \times 10^{-4}\ J}$

Medium

50) Find the time constants:

(a)

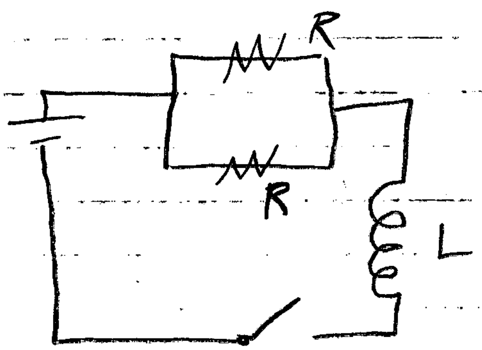


$R_{eq} = 2R$

$L_{eq} = L$

$\tau = L/R_{eq} = \boxed{\frac{L}{2R} = \tau}$

(b)



$R_{eq} = R/2$

$L_{eq} = L$

$\tau = \frac{L}{R/2} = \boxed{\frac{2L}{R} = \tau}$

Note: you must combine the resistors so you have a simple RL circuit before you can apply the formula $\tau = RC$.

Hard

16

$A = 100\ cm^2 = .01\ m^2$
$N = 200$
$R = 5\ \Omega$
$B_i = 1.1\ T$ up
$B_f = 1.1\ T$ down
$\Delta t = 0.1\ s$

find I_{ave}

Since the B field starts up and ends down we have a ΔB and thus a $\Delta \Phi_B$, which causes an induced EMF:

$$\mathcal{E}_{ind} = -N\frac{d\Phi_B}{dt} = -N\frac{\Delta B A}{\Delta t}$$

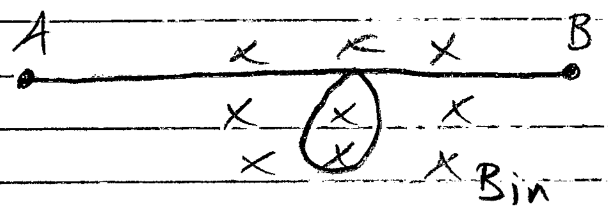
This EMF is going to drive a current through the resistor according to Ohm's law $V = IR$, combine and solve for I

$$IR = \frac{-N \Delta B A}{\Delta t} \longrightarrow I = \frac{-N \Delta B A}{R \Delta t}$$

$$I = \frac{-200\ (\overset{up}{1.1} - \overset{down}{-1.1})T(.01\ m^2)}{(5\ \Omega)(0.1\ s)} = \boxed{8.8\ A}$$

((−) sign is for direction only)

61



Kink $d_i = 2\ cm$
$d_f = 0\ cm$

The change in area causes an induced EMF

$$\mathcal{E}_{ind} = -N\frac{d\Phi}{dt} = \frac{-N B \Delta A}{\Delta t} \qquad \Delta A = \pi r_i^2 - \pi r_f^2$$

$$\boxed{\begin{array}{l} B = 25\ mT \\ \Delta t = 50\ ms \\ N = 1 \end{array}}$$

$$\boxed{\Delta A = \pi(.01\ m)^2 - 0}$$

plug in

Hard

16 cont

$$\mathcal{E}_{ind} = -1(25\,mT)\,\pi(.01\,m)^2 / 50\,ms$$

$$\boxed{\mathcal{E}_{ind} = 1.6\times10^{-4}\,V}$$

Now for polarity: Loop is shrinking, so flux into the page is decreasing. Induced flux would be into page, so current would flow clockwise in loop, corresponding to $A \to B$. Thus, since (+) charges will flow to point B, it will be at higher voltage.

(16) Kink area = constant, but but B increases to 100 mT in 4 ms.

Now $\mathcal{E} = -\dfrac{N\,\Delta B\,A}{\Delta t} = (100\,mT - 25\,mT)(\pi .01\,m^2)/4\,ms$

$$\boxed{\mathcal{E} = 5.89\,mV}$$

direction: flux into page increases, so induced flux is out of page, which is caused by a counterclockwise current, so (+) charges go to point A, so A is higher voltage.