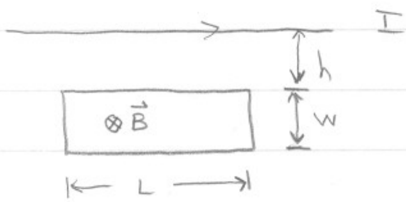
Solutions to hw 3

1) $\Phi_B = NAB\cos\theta \Rightarrow \Delta\Phi_B = 2NAB$ for flip. Thus,

$$\langle \mathcal{E} \rangle = -\frac{\Delta\Phi_B}{\Delta t} = -\frac{2NAB}{\Delta t}$$

where N is # turns, A is area of loop, and Δt is the time for flip.

my numbers: $N=15$, $d=1.1\,m$, $B=40\,\mu T$, $\Delta t = 0.199\,s \Rightarrow \langle \mathcal{E} \rangle = 5.73\,mV$

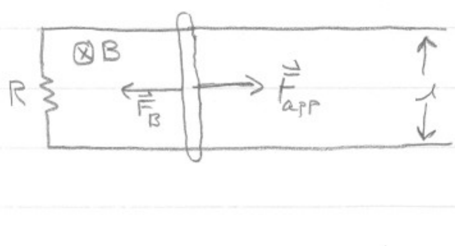


2a) $B = \frac{\mu_0 I}{2\pi r}$

$$\Phi_B = \frac{\mu_0 I L}{2\pi}\int_h^{h+w}\frac{dr}{r} = \frac{\mu_0 I L}{2\pi}\ln\frac{h+w}{h}$$

c+b) $I = a + bt \Rightarrow \frac{d\Phi_B}{dt} = \frac{\mu_0 b L}{2\pi}\ln\frac{h+w}{h}$; $b>0 \Rightarrow$ induced current is CCW

my numbers: $b = 15\,\frac{A}{s}$, $h = 1\,cm$, $w = 17\,cm$, $L = 140\,cm \Rightarrow \mathcal{E} = 12.1\,\mu V$ CCW



3) $\mathcal{E} = vBl \Rightarrow I = \frac{vBl}{R}$

$F = IBl = \frac{vB^2l^2}{R}$

$P = Fv = \frac{(vBl)^2}{R} = I^2R$

my numbers: $B = 2.5\,T$, $l = 1.2\,m$, $v = 1.7\,m/s$, $R = 6.5\,\Omega \Rightarrow F = 2.35\,N$

$P = 4.0\,W$

4) a: right b: out of page c: right d: into page

5) $2\pi r_2 E = \pi R^2 \frac{dB}{dt} \Rightarrow F = -e\frac{R^2}{2r_2}\frac{dB}{dt}$ where positive would be CCW.

$B = at^3 - bt^2 + c \Rightarrow \frac{dB}{dt} = 3at^2 - 2bt$

$\therefore F = 0$ when $t = 0$ or $t = \frac{2}{3}\frac{b}{a}$

my numbers: $r_2 = 2R = 5\,cm$, $a = 5\,T\,s^{-3}$, $b = 1\,T\,s^{-2}$

a) at $t = 2s$, $F = -5.6\times10^{-20}\,N$ is in CW direction

b) $F = 0$ at $t = 0.133\,s$

$\mathcal{E} = NAB\omega \sin \omega t$

my numbers: $N = 240$, $AB = 2.5\times10^{-4}\,T\,m^2$, $\omega = 2\times2\pi\times\frac{10^3}{60s} = 209.4\ rad/s$

$\mathcal{E}_{max} = 12.6\ V$

$P = \tau\omega = \mathcal{E}I = NIAB\omega \sin\omega t \Rightarrow \tau_{max} = NIAB \qquad P_{max} = \omega\tau_{max}$

my numbers: $N=60$, $A = 2.5\times4.0\,cm^2$, $B = 0.8T$, $I = 9A \Rightarrow \tau_{max} = 0.432\ Nm$

$\omega = 2\pi\times\frac{3100}{60s} = 324.6\,s^{-1} \Rightarrow P_{max} = 140.2\ W$

terminal speed $\Rightarrow mg = IBw = \frac{\mathcal{E}}{R}Bw = \frac{v(Bw)^2}{R}$

$\therefore\ B = \left(\frac{mgR}{vw^2}\right)^{1/2}$

my numbers: $m = 0.2\,kg$, $w = 1m$, $l = 1.5m$, $R = 0.85\,\Omega$, $v = 2m/s \Rightarrow B = 0.913$