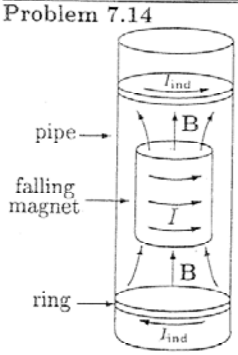
TFY 4240 Løsning Øving 7 2006

Problem 7.4

$I = J(s)\,2\pi sL \;\Rightarrow\; J(s) = I/2\pi sL.\quad E = J/\sigma = I/2\pi s\sigma L = I/2\pi kL.$

$V = -\int_b^a \mathbf{E}\cdot d\mathbf{l} = -\frac{I}{2\pi kL}(a-b).$ So $\boxed{R = \frac{b-a}{2\pi kL}.}$

Problem 7.14



Suppose the current (I) in the magnet flows counterclockwise (viewed from above), as shown, so its field, near the ends, points *upward.* A ring of pipe *below* the magnet experiences an increasing upward flux, as the magnet approaches, and hence (by Lenz's law) a current (I_{ind}) will be induced in it such as to produce a *downward* flux. Thus I_{ind} must flow *clockwise*, which is *opposite* to the current in the magnet. Since opposite currents repel, the force on the magnet is *upward.* Meanwhile, a ring *above* the magnet experiences a *decreasing* (upward) flux, so *its* induced current is *parallel* to I, and it *attracts* the magnet upward. And the flux through rings *next to* the magnet is constant, so *no* current is induced in them. *Conclusion:* the delay is due to forces exerted on the magnet by induced eddy currents in the pipe.

blem 7.20

'rom Eq. 5.38, the field (on the axis) is $\mathbf{B} = \frac{\mu_0 I}{2}\frac{b^2}{(b^2+z^2)^{3/2}}\hat{\mathbf{z}}$, so the flux through the little loop (area πa^2)

$\boxed{= \frac{\mu_0 \pi I a^2 b^2}{2(b^2+z^2)^{3/2}}.}$

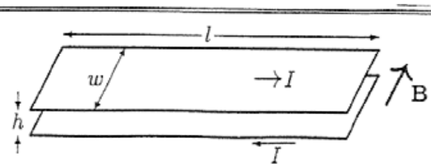
'he field (Eq. 5.86) is $\mathbf{B} = \frac{\mu_0}{4\pi}\frac{m}{r^3}(2\cos\theta\,\hat{\mathbf{r}} + \sin\theta\,\hat{\boldsymbol{\theta}})$, where $m = I\pi a^2$. Integrating over the spherical "cap" nded by the big loop and centered at the little loop):

$$\Phi = \int \mathbf{B}\cdot d\mathbf{a} = \frac{\mu_0}{4\pi}\frac{I\pi a^2}{r^3}\int (2\cos\theta)(r^2\sin\theta\,d\theta\,d\phi) = \frac{\mu_0 I a^2}{2r}2\pi\int_0^{\bar\theta}\cos\theta\sin\theta\,d\theta$$

e $r = \sqrt{b^2+z^2}$ and $\sin\bar\theta = b/r$. Evidently $\Phi = \frac{\mu_0 I \pi a^2}{r}\left.\frac{\sin^2\theta}{2}\right|_0^{\bar\theta} = \boxed{\frac{\mu_0 \pi I a^2 b^2}{2(b^2+z^2)^{3/2}},}$ the same as in (a)!!

'ividing off I ($\Phi_1 = M_{12}I_2$, $\Phi_2 = M_{21}I_1$): $\boxed{M_{12} = M_{21} = \frac{\mu_0 \pi a^2 b^2}{2(b^2+z^2)^{3/2}}.}$

Problem 7.58



(a) Parallel-plate capacitor: $E = \frac{1}{\epsilon_0}\sigma;\; V = Eh = \frac{1}{\epsilon_0}\frac{Q}{wl}h \Rightarrow C = \frac{Q}{V} = \frac{\epsilon_0 wl}{h} \Rightarrow \boxed{\mathcal{C} = \frac{\epsilon_0 w}{h}.}$

(b) $B = \mu_0 K = \mu_0\frac{I}{w};\; \Phi = Bhl = \frac{\mu_0 I}{w}hl = LI \Rightarrow L = \frac{\mu_0 h}{w}l \Rightarrow \boxed{\mathcal{L} = \frac{\mu_0 h}{w}.}$

(c) $\boxed{\mathcal{CL} = \mu_0\epsilon_0} = (4\pi\times 10^{-7})(8.85\times 10^{-12}) = \boxed{1.112\times 10^{-17}\,\text{s}^2/\text{m}^2.}$

(Propagation speed $1/\sqrt{\mathcal{LC}} = 1/\sqrt{\mu_0\epsilon_0} = 2.999\times 10^8\,\text{m/s} = c.$)

(d) $D = \sigma,\; E = D/\epsilon = \sigma/\epsilon$, so just replace ϵ_0 by ϵ;
$H = K,\; B = \mu H = \mu K$, so just replace μ_0 by μ.
$\boxed{\mathcal{LC} = \epsilon\mu;}$ $\boxed{v = 1/\sqrt{\epsilon\mu}.}$