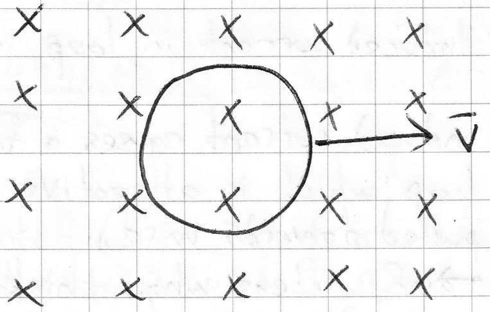
Tutorial Problems (Giordano ch. 21)

3/5/13

Q8

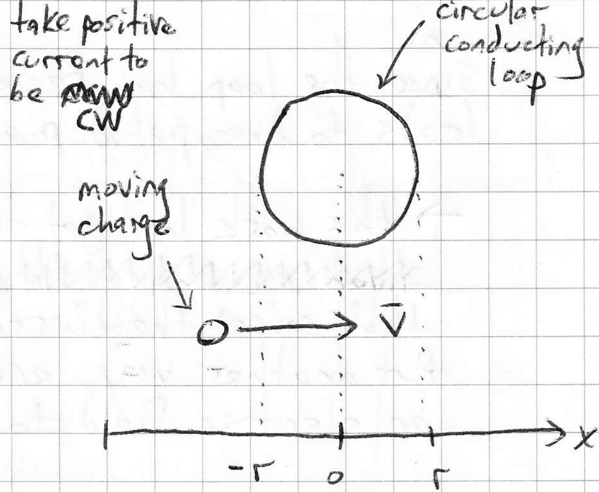


- conducting loop pulled at const. velocity through region of const. magnetic field

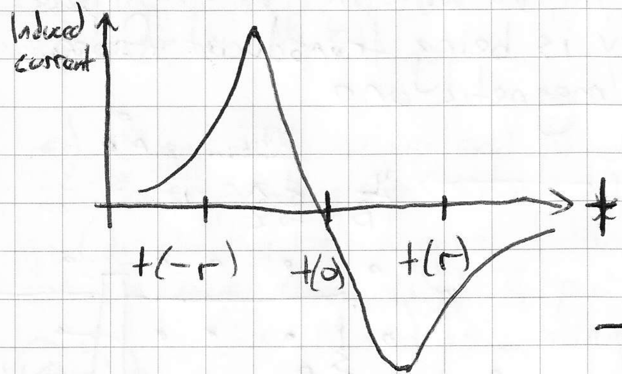
→ induced $\mathcal{E}$ is zero because:
- area not changing
- orientation of loop not changing
- strength of $\bar{B}$ is constant

thus Φ_B = const. (i.e. $d\Phi_B/dt = 0$)

Q7 | P7



- charged particle moves near a conducting loop. Make a qualitative sketch of the induced current

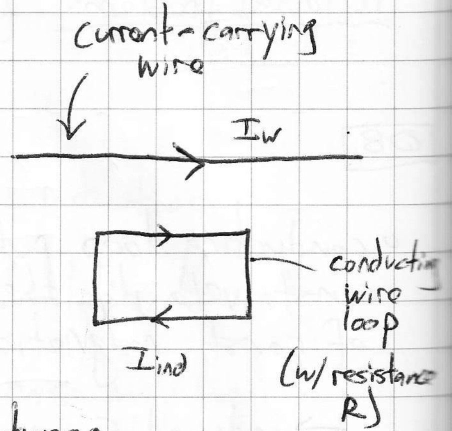


→ same idea applies to P21.7

NOTE: because of the increase and then decrease in flux, we get an **alternating current**

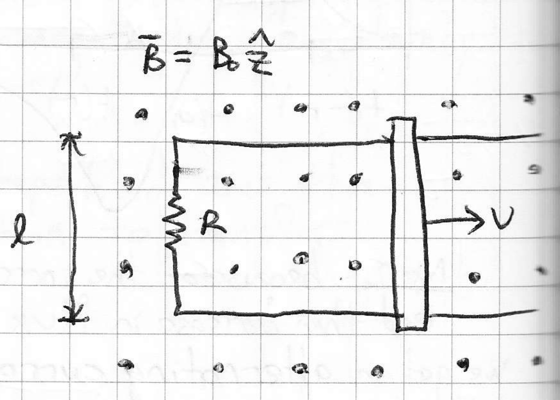
3/5/13

P21 wire current <u>decreasing</u> w/ time (I_w)



- Induced current in loop is **clockwise**
- induced current causes a force on the loop which is attractive (i.e. loop is pulled towards wire)
  → if unclear why, think about forces between current-carrying wires (e.g. same direction = attractive force) superposition (i.e. consider each side of the loop separately, then add them together), and that the strength of the field falls off as 1/r (r ≡ radial distance from wire)
- Since the loop has resistance R, the induced current leads to dissipated power ($P = I_{ind}^2 R$)
  → this work has got to come from the voltage source ~~[illegible]~~ that caused the current in the wire in the first place. Put another way, energy is being transduced from an electric field to a magnetic one

P25



$R = 200\,\Omega$
$B_0 = 1.5\ T$
$l = 0.6\ m$
$v = 25\ m/s$

P25 (cont.)

since $V = \frac{dx}{dt}$ and x is the 'length' of the surface

$$\frac{d\Phi_B}{dt} = B\frac{dA}{dt} = B\ell V = -\mathcal{E} = -IR$$

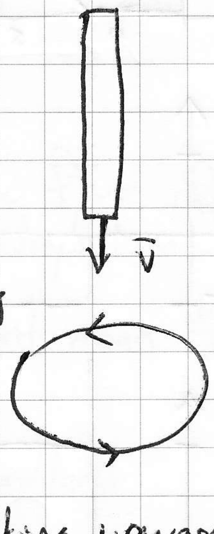
$$\rightarrow |I| = \frac{B\ell V}{R} = \frac{(1.5\,T)(0.6\,m)(25\,m/s)}{(200\,\Omega)} = 0.12\,A$$

- Note that the current is negative, but it is not clear what this means without an appropriate reference. Consider Lenz's Law:

  since $\frac{d\Phi_B}{dt} > 0$, the induced current must create B_{ind} going <u>into</u> the page so to resist the change. Using the RHR, this must mean that I_{ind} is **clockwise**

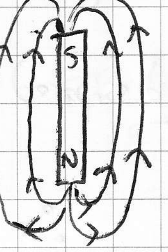
∴

P29 (this problem relates to our falling magnet / copper tube demo)



- bar magnet is dropped, heading towards a wire loop. A current is induced that is CCW in the loop

a) S end must be up and N end down: $\bar{B}_{ind}$ is pointing up. Since Φ_B is increasing (due to the bar magnet falling), $\bar{B}_{ind}$ pointing up must mean that $\bar{B}$ points down (i.e. N end is coming first)



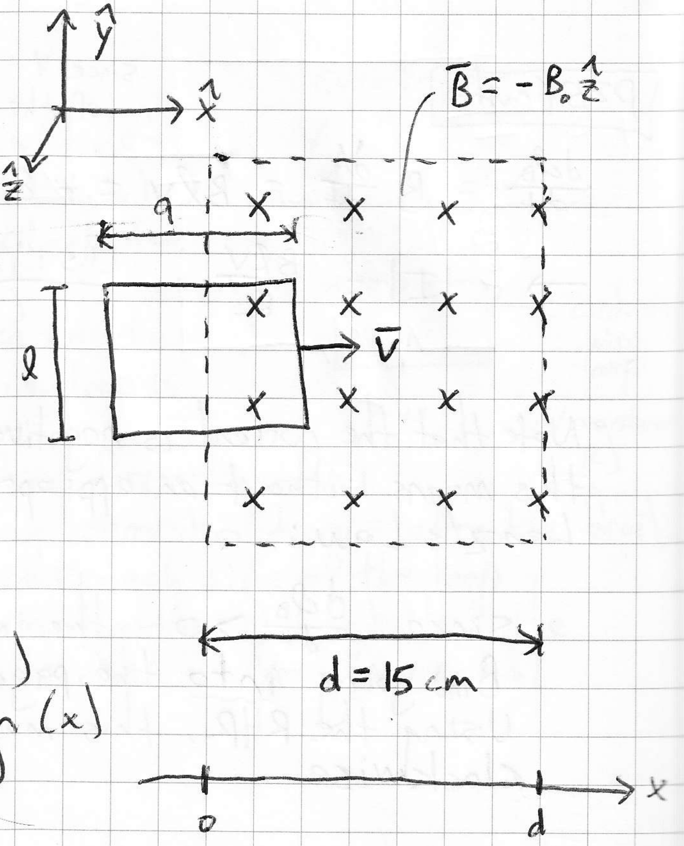
b) The induced magnetic field leads to a force on the magnetic pointing upwards

c) Reorienting the magnet changes direction of induced current, but not force ∴

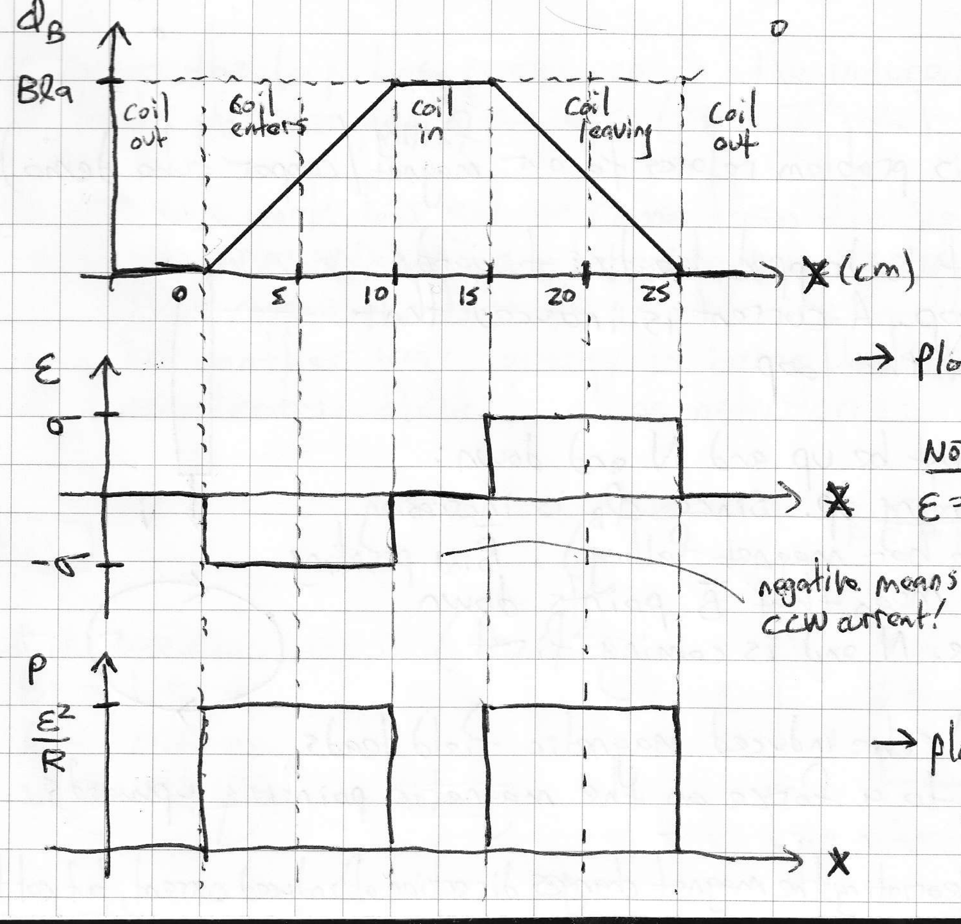
3/5/13

ax (not in Giordano)

Consider a rectangular loop (of resistance R, width l and length a) being pulled ~~at~~ const. velocity (v) through a region of uniform magnetic field ($\bar{B}$) created by an external magnet.



a) plot Φ_B (flux through coil) as a function of coil position (x) (assume $l = 4$ cm $< d$)



→ plot the induced EMF

NOTE

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d\Phi_B}{dx}\frac{dx}{dt} = -\frac{d\Phi_B}{dx} v = \sigma$$

→ plot the dissipated power