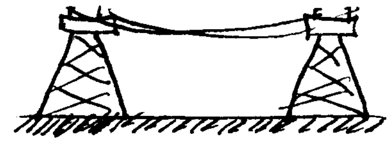
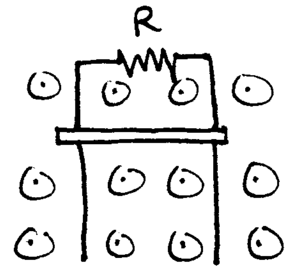


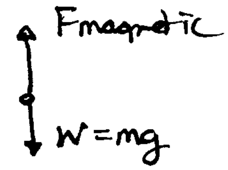
(C20) HIGH VOLTAGE power lines run next to Old MacDONALD's field. How can he (illegally) steal power?

DC: If the power lines carry direct current, he can put little loops of wire on his cows connected to rechargeable batteries. As the cows walk closer and farther from the power lines the strength of B changes, so the flux thru the loops changes. If the flux changes in the loops, a current is induced, which charges the batteries.

AC: If the power lines carry alternating current, he can simply put loops of wires near the powerlines, with the loops connected to the electrical inputs to his house. Since the current alternates in the power lines, the magnetic field they generate is constantly changing. As such the wire loops see a constantly changing flux and a current is induced to power the farmer's house.



⑤ A 1.30 m long rod massing 15.0 g slides down two vertical rails as shown. The rails are connected by an 8.0 Ω resistor and are immersed in a 0.450 T field. (a) What is the terminal velocity of the rod?
(b) At terminal velocity how does change in gravitational potential energy compare to the power dissipated in the resistor?



The free body diagram is shown to the right. At terminal velocity, $a \to 0$ so all forces must sum to zero. The magnetic force can be written for currents. The current in question is the <u>INDUCED</u> current that results from the bar falling and increasing the <u>FLUX</u> through the enclosed part of the circuit.

$F = I\ell B$ magnetic force INDUCED EMF $\mathcal{E}_{IND} = vB\ell$

Given the induced EMF the current is: $\mathcal{E} = IR \rightarrow I = \frac{\mathcal{E}}{R} = \frac{vB\ell}{R}$

so//

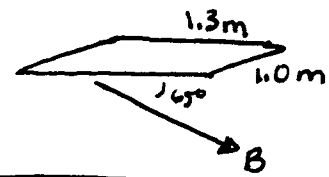
$$F_{mag} = I\ell B = \frac{vB^2\ell^2}{R}.$$

Since $F_{mag} = F_{grav}$ we get: $\frac{vB^2\ell^2}{R} = mg \rightarrow v = \frac{mgR}{B^2\ell^2}$

so//

$$v = \frac{(0.015\,kg)(9.81\,m/s^2)(8.0\,\Omega)}{(0.450\,T)^2\,(1.30\,m)^2} = \boxed{3.44\,m/s = v}$$ (ANS)

(10) My LEGO desk measures 1.3 m x 1.0 m. The Earth's field has a magnitude 0.44 mT, directed 65° below horizontal. What is flux?

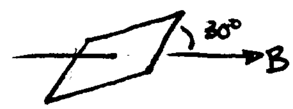


Flux is given by: $\Phi = B \cdot A \cdot \cos\theta$ ← angle to ⊥ of desk

so//

$$\Phi = (0.44\times10^{-3}\,T)(1.3\,m \cdot 1.0\,m)(\cos 25°) = \boxed{5.2\times10^{-4}\,Tm^2}$$ (ANS)

(11) A square loop of wire 0.75 m per side, has a 0.32 T field pointing 30° from its surface.



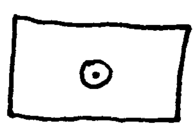
(a) What is flux thru loop? (b) If angle to surface increases to 60° what is new flux? (c) While angle is increasing what is direction of current?

(a) Flux given by: $\Phi = BA\cos\theta$ ← angle to ⊥ of loop

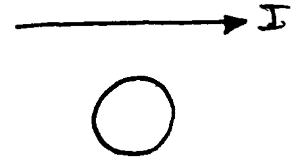
so// $\Phi = (0.32\,T)(0.75\,m \cdot 0.75\,m)(\cos 60°) = \boxed{0.09\,Tm^2}$ (ANS)

(b) Increasing angle to 60° means $\theta = 30°$ so:

$$\Phi = (0.32\,T)(0.75\,m \cdot 0.75\,m)(\cos 30°) = \boxed{0.156\,Tm^2}$$ (ANS)

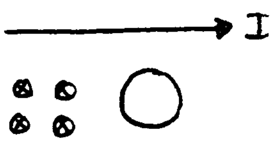
(c) 

If I look down the field as shown, as the loop rotates the flux INCREASES. The loop doesn't like that so it reduces the flux by inducing the current in the CLOCKWISE direction.



(12) Consider the wire and loop shown to the right.
(a) Loop comes closer to the current, which direction does the induced current flow? (b) If the induced EMF is 3.5 mV, what is the rate of change of flux in Tm^2/s?

(a)



The field from the wire is into the page thru the loop. As the loop gets closer the field increases in strength the flux goes up. The loop doesn't like that, so tries to DECREASE the flux by inducing a current in the CCW direction.

(b) Faraday's law relates EMF to the rate of change in magnetic flux:

$$\mathcal{E} = N \frac{\Delta\Phi}{\Delta t} \rightarrow \underset{N=1}{\text{ONE LOOP}} \rightarrow \frac{\Delta\Phi}{\Delta t} = \mathcal{E}$$

Soll

$$\frac{\Delta\Phi}{\Delta t} = 3.5\,mV = 3.5\times10^{-3}\,V = \boxed{3.5\times10^{-3}\,\frac{Tm^2}{s}}$$ (ANS)

(15) Show that $1\frac{Wb}{s} = 1V$ (IE that $\Delta\Phi/\Delta t$ can be measured in volts):

$$\frac{1\,Wb}{1\,s} = \frac{1T\cdot 1m^2}{s} = \frac{1\frac{N}{A\cdot m}\cdot m^2}{s} = \frac{\frac{Ns}{Cm}\,m^2}{s} = \frac{Nm}{C} = \frac{J}{C} = V$$

Q.E.D.

(26) The doorbell to NASA Headquarters uses a transformer to deliver 8.5V when connected to a 170V supply at the primary. If the secondary has 50 turns, what is the Turns ratio? How many turns does the primary have?

The turns ratio is given in terms of the transformer voltage ratio.

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{8.5\ V}{170\ V} = \boxed{1:200 = \frac{N_2}{N_1}}$$ (ANS)

So// $N_1 = N_2 \cdot 200 = 50 \cdot 200 = \boxed{10000}$ (ANS)

(31) The answering machine at Starfleet HQ takes 170V in and outputs 7.8V. The primary has 300 turns. (a) How many turns on the secondary?
(b) If the machine uses 5.0W of power, what is the current drawn from the 170V line?

(a) Turns can be found from the voltage ratio:

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{N_1}{N_2} \rightarrow N_2 = \frac{N_1 \cdot \mathcal{E}_2}{\mathcal{E}_1} = \frac{(300)(7.8V)}{(170V)} = 13.8 \doteq \boxed{14} \text{ (ANS)}$$

(b) Power is related to current by: $P = IV = I\mathcal{E}$
where $\mathcal{E}$ is the EMF in the coil of interest, so the current in the machine is:

$$I = P/\mathcal{E} = 5.0W/ \quad = \quad \text{Amp.}$$