ECE330: Power Circuits & Electromechanics

Review. Magnetic circuits

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Schedule

- Mon 2/24: Review
- Wed 2/26: Review
- **Thu 2/27: Exam 1**
- Fri 2/28: No class

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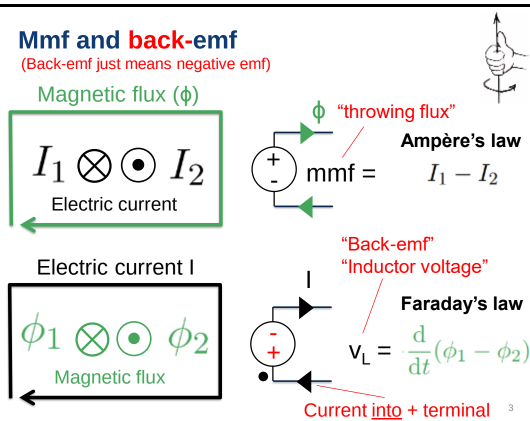
Mmf and back-emf

(Back-emf just means negative emf)



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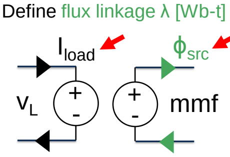
Important

Flux linkage

Voltage depends on flux direction and number of turns

$$v_L = +N\frac{d\phi}{dt}$$

Define flux linkage λ [Wb-t] to absorb both sources of error



$$\lambda = N\phi_{src} \qquad = Li_{load} \text{ (linear inductor)}$$

$$v_L = \frac{d\lambda}{dt} \qquad = L\frac{di}{dt}$$

In circuit theory, flux linkage λ is the *dual* of charge q

$$i_C = \frac{dq}{dt} = C\frac{dv}{dt}$$

Polarity of flux & current

Polarity of mmf

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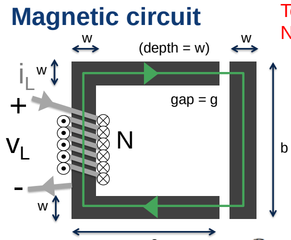
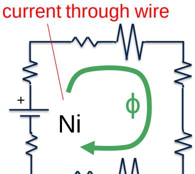
Important

Magnetic circuit



Total net current = N x current through wire



Total flux linkage = N x flux

Inductance L

$$\lambda = N\phi = \frac{N^2}{\mathcal{R}_{core} + \mathcal{R}_{gap}} i$$

$$v_L = \frac{d\lambda}{dt} = \frac{N^2}{\mathcal{R}_{core} + \mathcal{R}_{gap}} \frac{di}{dt}$$

$$\mathcal{R}_{core} = \frac{1}{\mu_0\mu_r} \frac{\text{av. path len.}}{\text{cross-sec. area}} = \frac{2a + 2b - 2w}{\mu_0\mu_r w^2} \qquad \mathcal{R}_{gap} = \frac{2g}{\mu_0 w^2}$$

Flux density = total flux / area

$$B = \phi/A \quad \text{Wb/m}^2$$

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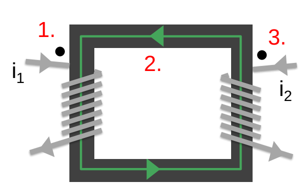
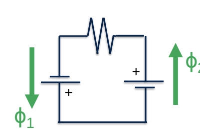
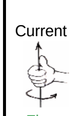
Important

Dots and associated magnetic circuit







1. Place a dot at coil 1. (Your choice)
2. Inject current into the dot, and determine flux direction using right-hand rule
3. Mark dot at coil 2 to achieve the same flux direction

If i_1 and i_2 into dots, ϕ_1 and ϕ_2 should agree

Implies M ≥ 0

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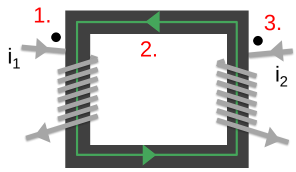
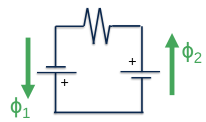
Important

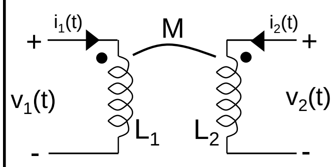
Reference model – Current into dots





If i_1 and i_2 into dots, ϕ_1 and ϕ_2 should agree

Implies M ≥ 0



$$\lambda_1 = L_1 i_1 + M i_2$$
$$\lambda_2 = M i_1 + L_2 i_2$$

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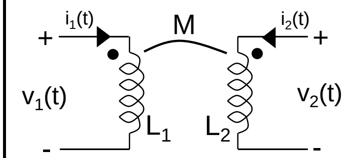
Important

Reference model – Current into dots

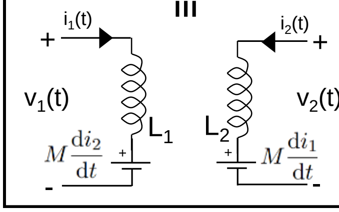


Polarity

v pos. terminal at dot
i flows into dot

$$\lambda_1 = L_1 i_1 + M i_2$$
$$\lambda_2 = M i_1 + L_2 i_2$$

III



$$v_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$
$$v_2 = M \frac{di_1}{dt} + L_2 \frac{di_2}{dt}$$

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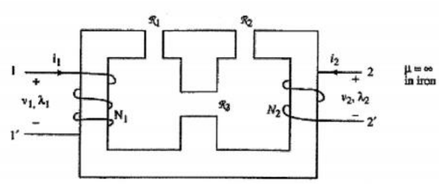
Problem 3 from Exam 1 of Fall 2008

3. (25 points)

Two coils are coupled through the iron of the magnetic circuit shown below.

a) Place the dots on the appropriate terminals of the two coils
b) Write all of the equations that you would need to find the two flux linkages in terms of the two currents (do not solve).



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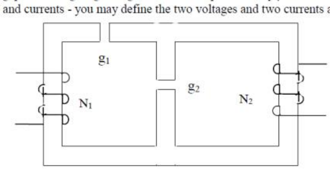
Problem 4 from Exam 1 of Fall 2017

Problem 4. (25 points)

A multi-coil magnetic circuit is illustrated in the diagram below. The cross-sectional area of the magnetic core is A everywhere. The permeability of the magnetic core is infinite. There are two air gaps with lengths g_1 and g_2 as shown and permeability μ_o. You may neglect fringing. Label the voltages and currents - you may define the two voltages and two currents any way that you like.



a) (5 pts) Put the polarity "dots" on the proper side of each coil
b) (10 pts) Find expressions for L1, L2, and M in terms of the parameters
c) (5 pts) Find an expression for the coefficient of coupling in terms of only g1 and g2
d) (5 pts) What happens to the coefficient of coupling as g1 gets smaller and g2 gets bigger?

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Problem 4 from Exam 1 of Fall 2013

Problem 4. (25 points)

Two identical coils (each with zero resistance) are located near each other. Coil #2 is open circuited.

When a 60Hz sinusoidal voltage of 120 Volts (RMS) is applied to coil #1, the coil #1 current is 6 Amps (RMS) and the voltage measured on the open-circuited coil #2 is 70 Volts (RMS).

(a) What are the self inductances of coil #1 and #2 in Henries?

(b) What is the magnitude of the mutual inductance between coil #1 and coil #2 in Henries?

(c) What are the current magnitudes in coil #1 and #2 if a short circuit is placed across coil #2 while the given voltage is applied across coil #1?

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