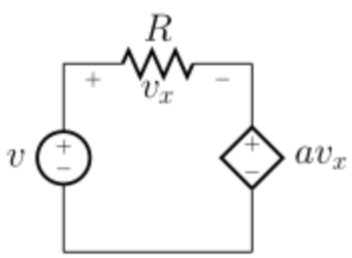
Discussion 1B (Week2)

Thursday, April 8, 2021   8:59 AM

Today:
- **Review Quiz #3 answers**
- **Ideal transformers**
- **Resistive networks**
- Example Questions
- Magnetics review (https://www.ieee.li/pdf/introduction_to_power_electronics/chapter_12.pdf)

Quiz #3 Review:



Q2b.) not solvable

if $I = 1A$ was provided?

KVL: $V = IR + aV_x$

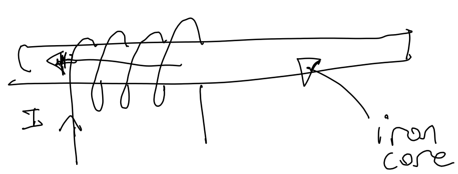
$V_x = IR$

$\rightarrow V = IR + aIR = (1+a)IR$

$V = 100V$, $R = 20\Omega$, $I = 1A$

$100 = (1+a)\,20 \rightarrow \boxed{a = 4}$ ☆

Inductance (Sections 3.4 – 3.7)



magnetic field direction determined by the "right-hand rule"

$\boxed{V = L\frac{di}{dt}}$

- when current changes $\left(\frac{di}{dt} \neq 0\right)$ the resulting magnetic flux, Φ, changes
- time-varying magnetic flux in a coil induces a voltage across the coil

What happens if $I = 1A$ (constant), what is the voltage across the inductor?

$V = 0$

$C = \frac{\varepsilon A}{d}$

② Energy stored in an inductor

$E_{capacitor} = \frac{1}{2} CV^2$

$P = IV$

$E_{inductor} = \int P \cdot dt$

* provide: $i(t=0^-) = 0$ (initial condition)

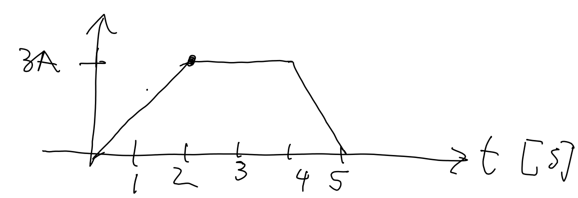
$E_{inductor} = \int_0^t P \cdot dt$

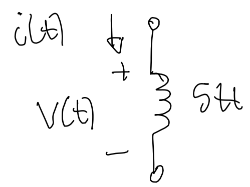
$P = IV = i(t) \times \left(L \frac{di}{dt}\right)$

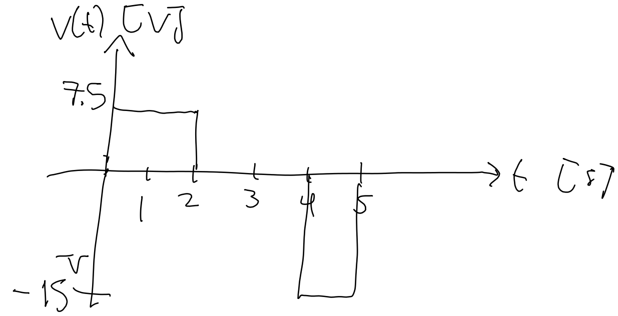
$E_{inductor} = \int_0^t i(t) \times L \frac{di}{\cancel{dt}} \cancel{dt} = \int_0^t i(t) \times L\, di$

$$\boxed{= \frac{1}{2} L i^2}$$

Example #1: $V = L\frac{di}{dt}$







① $t=0 \to t=2$:

$\frac{di}{dt} = \frac{3}{2} \to$

$V = L\frac{di}{dt} = (5H) \times \frac{3}{2} = 7.5$

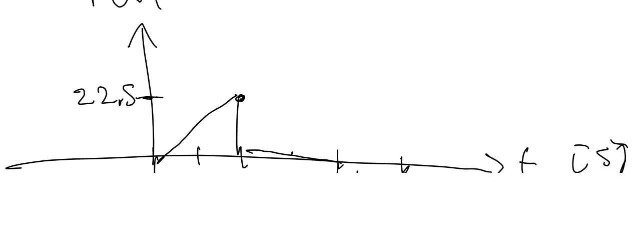
② $t=2 \to t=4$:

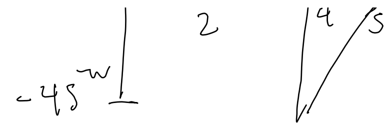
$\frac{di}{dt} = 0 \to V = 0$

③ $t=4 \to t=5$:

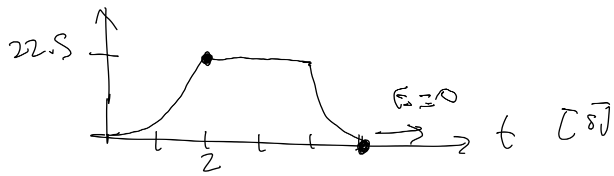
$\frac{di}{dt} = -3 \to V = 5 \times (-3) = -15V$

$P(t) = I(t) \times V(t)$ [W]





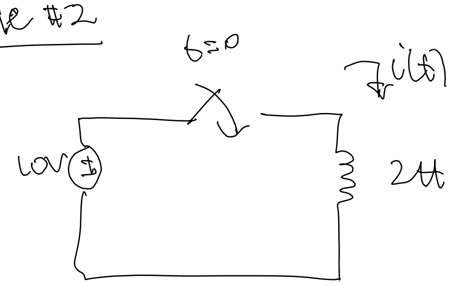
$E(t) = \int p \cdot dt$

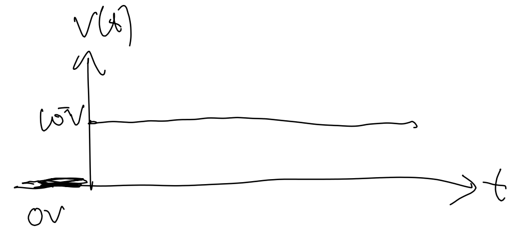


$t=2$: $E_1 = \int_0^2 p(t)dt = \int_0^2 \left(\frac{22.5}{2} t\right) dt = \frac{22.5}{2} \times \frac{1}{2} t^2 \Big|_0^2$
$= \underline{22.5\ J}$

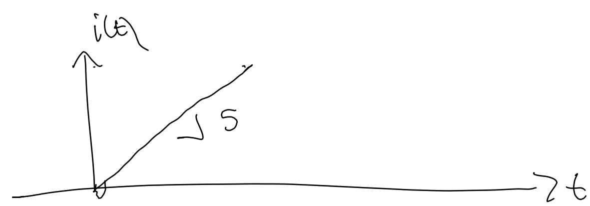
$t=4 \rightarrow t=5$:
$E_2 = \int_4^5 (45t - 225)\,dt = \left[\frac{45t^2}{2} - 225t\right]\Big|_4^5 = \boxed{-22.5\,J}$

Example #2





$V = L\frac{di}{dt} \rightarrow \frac{di}{dt} = \frac{V}{L} = \frac{10V}{2H} = 5$



What happens as $t \rightarrow \infty$?

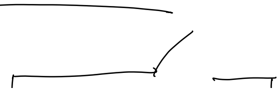
$i(t) \rightarrow \infty$

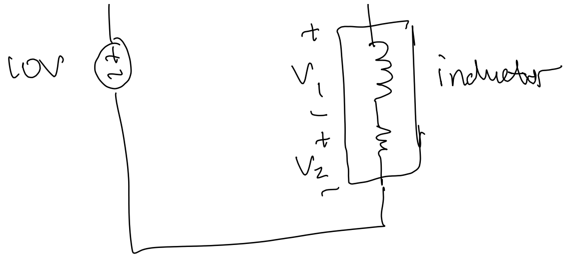
not realistic.
↳ circuit break, i cannot ∞

Example #3 :

Capacitor : 

inductor : 





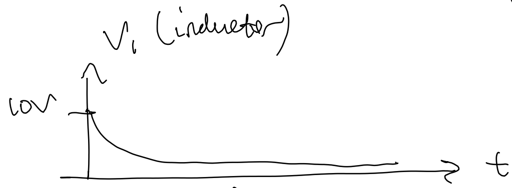
R_{par} parasitic resistance

$$V(t) = iR_{par} + L\frac{di}{dt}$$

outside of scope of class

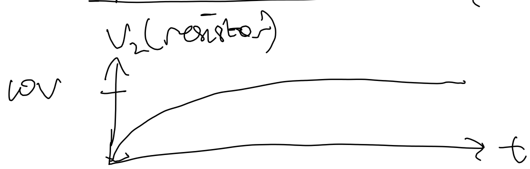
$$\hookrightarrow \quad I(t) = \frac{V}{R}\left(1 - e^{-\frac{R_{par}}{L}t}\right)$$

$$I(\infty) = \frac{V}{R}$$



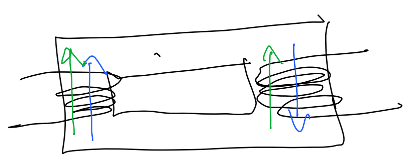
* called:

resistance-limited circuit



Transformers

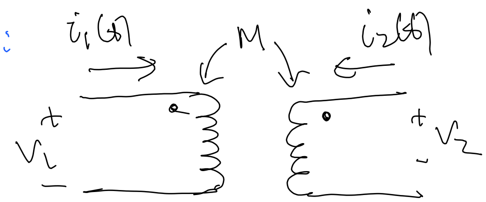
(Ideal transformer: 14.5
↳ for EM review: 14.1-14.4)



* aids
* opposing

(direction of $\vec{B}$ determined by right hand rule)

① aids:

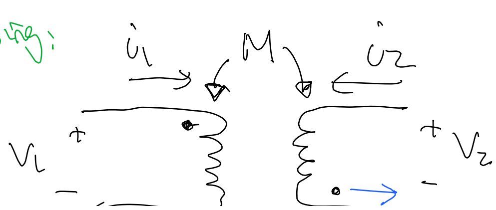


$$V_1 = L_1\frac{di_1}{dt} + M_{21}\frac{di_2}{dt}$$

$$V_2 = L_2\frac{di_2}{dt} + M_{12}\frac{di_1}{dt}$$

Note: $M_{12} = M_{21} = M$

② opposing:

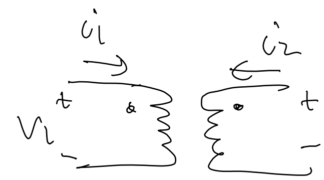


" i_2 flowing out of the dot "

$$V_1 = L_1\frac{di_1}{dt} - M\frac{di_2}{dt}$$

$$V_2 = L_2 \frac{di_2}{dt} - M \frac{di_1}{dt}$$

Example #4:



$L_1 = 1H, \quad L_2 = 2H, \quad M = 1H$

$i_1(t) = \sin(10t)\,[A] \quad i_2(t) = \frac{1}{2}\sin(10t)\,[A]$

What is $V_1(t)$ & $V_2(t)$?

$$\boxed{\begin{aligned} V_1(t) &= 15\cos(10t) \quad [V] \\ V_2(t) &= 20\cos(10t) \quad [V] \end{aligned}}$$

note: $H = \Omega \cdot s$
(for units)

Ideal Transformers (Section 14.5)

* coupling coefficient

$$k = \frac{\sqrt{L_1 L_2}}{M} \qquad (0 \le k \le 1)$$

$k = 1$: perfect coupling

* ideal transformer, we assume perfect coupling

$$V_1(t) = N_1 \frac{d\Phi_1}{dt} \qquad V_2(t) = N_2 \frac{d\Phi_2}{dt}$$

$$\Phi_1 = \Phi_2 = \Phi$$

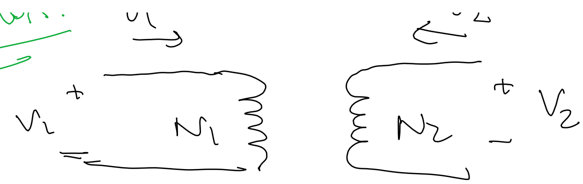
$$V_2(t) = N_2 \frac{d\Phi}{dt} = N_2\left(\frac{V_1}{N_1}\right) = \underbrace{\frac{N_2}{N_1}}\, V_1$$

$n = \frac{N_2}{N_1}$ ("turns ratio")

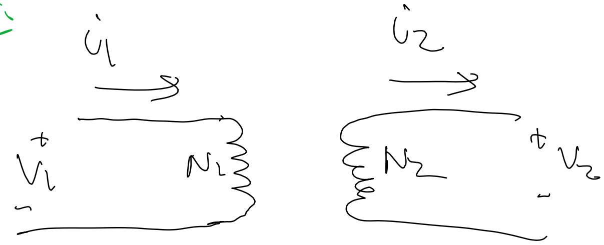
$\frac{N_s}{N_p}$ (secondary) (primary)

$$\boxed{i_2 = \frac{-i_1}{\left(\frac{N_2}{N_1}\right)} = \frac{-N_1}{N_2} i_1 = \frac{-1}{n} i_1}$$

convention:



textbook:



$$\therefore \quad i_2 = \frac{1}{n} i_1 = \frac{N_1}{N_2} i_1$$

Office hours today:

- Thursday (4/8) 1–2pm PDT (weekly)

  4:30–5pm PDT (today o.

using same zoom links as discussion