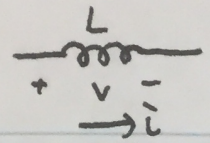
* Inductor



$$v = L\frac{di}{dt}$$

- $i = \text{const} \Rightarrow v = 0 \Rightarrow$ short circuit
- $i(t) = \frac{1}{L}\int_{t_0}^{t} v\,d\tau + i(t_0)$
- power: $p = vi = L\frac{di}{dt}\cdot i$

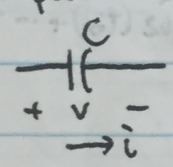
$$= v\cdot\frac{1}{L}\int_{t_0}^{t} v\,d\tau + i(t_0)$$

- energy: $p = \frac{dw}{dt} = L\frac{di}{dt}\cdot i$

$$dw = L\,di\cdot i$$

$$w = L\int_0^{i} l\,dl = \frac{1}{2}Li^2$$

* Capacitor



$$i = C\frac{dv}{dt}$$

- $v = \text{const} \Rightarrow i = 0 \Rightarrow$ open circuit
- $v(t) = \frac{1}{C}\int_{t_0}^{t} i\,d\tau + v(t_0)$
- power: $p = vi = v\cdot C\frac{dv}{dt}$

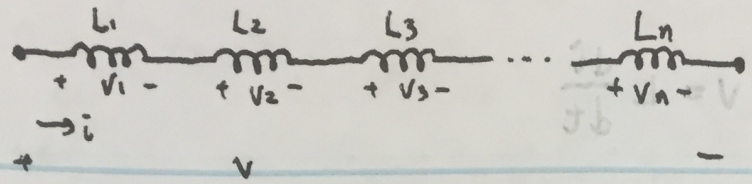
$$= \left[\frac{1}{C}\int_{t_0}^{t} i\,d\tau + v(t_0)\right]\cdot i$$

- energy: $p = \frac{dw}{dt} = v\cdot C\frac{dv}{dt}$

$$dw = Cv\,dv$$

$$w = C\int_0^{v} v\,dv = \frac{1}{2}Cv^2$$

* Inductors in series

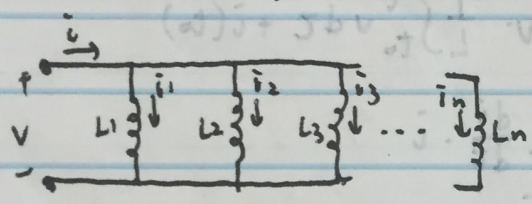


$$V = V_1 + V_2 + V_3 + \cdots + V_n$$

$$= (L_1 + L_2 + \cdots + L_n)\frac{di}{dt}$$

$$L_{eq} = L_1 + L_2 + \cdots + L_n$$

* Inductors in parallel

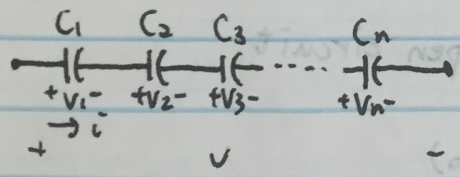


$$i = i_1 + i_2 + i_3 + \cdots + i_n$$

$$= \left(\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_n}\right)\int_{t_0}^{t} v\,d\tau + i_1(t_0) + i_2(t_0) + \cdots + i_n(t_0)$$

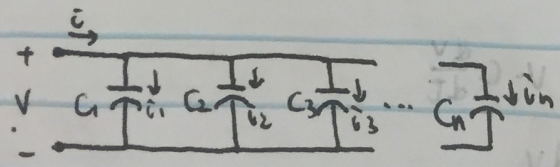
$$\therefore \frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}, \quad i(t_0) = i_1(t_0) + i_2(t_0) + \cdots + i_n(t_0)$$

* Capacitors in series

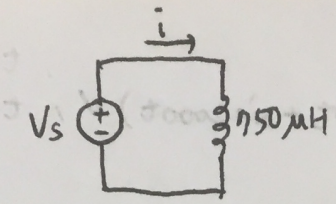


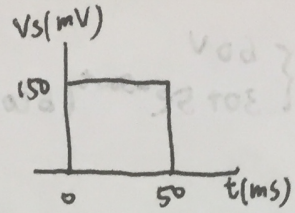
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}, \quad V(t_0) = V_1(t_0) + V_2(t_0) + \cdots V_n(t_0)$$

* Capacitors in parallel



$$C_{eq} = C_1 + C_2 + C_3 + \cdots + C_n$$





i is known to be zero for $t \le 0$

(a) Derive the expressions for i for $t \geq 0$

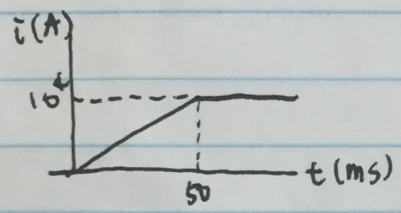
(b) Sketch i versus t for $0 \le t \le \infty$

(a) $i(0) = 0$

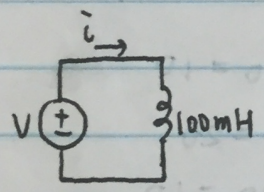
$$i(t) = \frac{1}{L}\int_0^t v\,d\tau + i(0) = \frac{1}{750\mu} \cdot 150 = t, \quad 0 \le t \le 50$$

$$i(50) = \frac{1}{750\mu}\int_0^{50} 150\,d\tau + 0 = 10^4, \quad t > 50$$

(b)



$$i = \begin{cases} t, & 0 \le t \le 50 \\ 10, & t > 50 \end{cases}$$



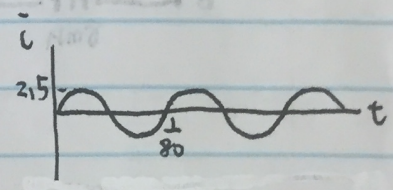
$V = 20\cos 80t$, $i(0) = 0$ A.

Find i, p, and w for $t \geq 0$

$$i(t) = \frac{1}{0.1}\cdot\int_0^t 20\cos 80\tau\,d\tau + 0$$

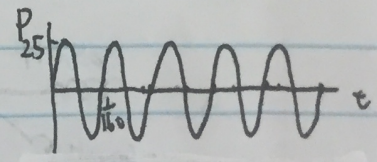
$$= \frac{1}{0.1}\cdot 20\cdot\frac{1}{80}\sin 80t$$

$$= 2.5\sin 80t \text{ A}$$



$$p(t) = vi = 20\cos 80t \cdot 2.5\sin 80t$$

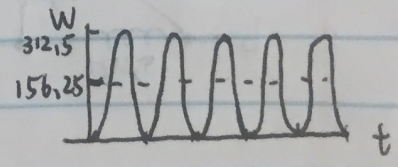
$$= 25\sin 160t \text{ W}$$

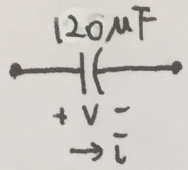


$$w(t) = \frac{1}{2}Li^2$$

$$= 312.5\sin^2 80t$$

$$= -156.25\cos 160t + 156.25 \text{ mJ}$$





$$V = \begin{cases} 60\,V & , t \le 0 \\ 30 + 5e^{-500t}(6\cos 2000t + \sin 2000t)\,V & , t \ge 0 \end{cases}$$

Find i for $t<0$, $t>0$.

$$i = C\frac{dv}{dt} = \begin{cases} 0, & t<0 \\ [-2500e^{-500t}(6\cos 2000t + \sin 2000t) \\ \quad + 5e^{-500t}(-12000\sin 2000t + 2000\cos 2000t)]\cdot 120\mu, & t>0 \end{cases}$$

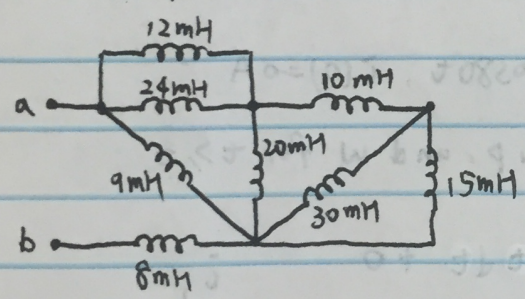
$$\Rightarrow i = \begin{cases} 0, & t<0 \\ -300e^{-500t}(2\cos 2000t + 25\sin 2000t)\,m, & t>0 \end{cases}$$ #

How much energy is stored in the capacitor at $t=\infty$?

$V(\infty) = 30$

$W = \frac{1}{2}CV^2 = 54\ mJ$ #

Find the equivalent inductance with respect to a, b



$15 \parallel 30 = 10$

$10 + 10 = 20$

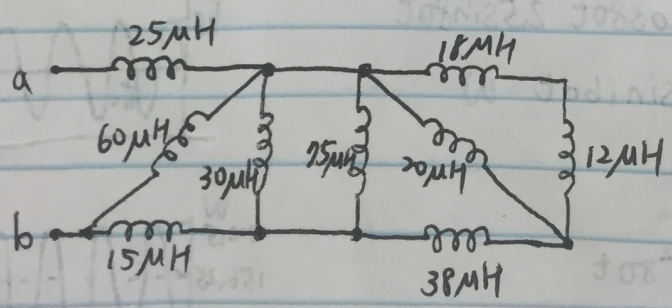
$20 \parallel 20 = 10$

$12 \parallel 24 = 8$

$10 + 8 = 18$

$18 \parallel 9 = 6$

$6 + 8 = 14\ mH$ #



$12 + 18 = 30$

$30 \parallel 20 = 12$

$12 + 38 = 50$

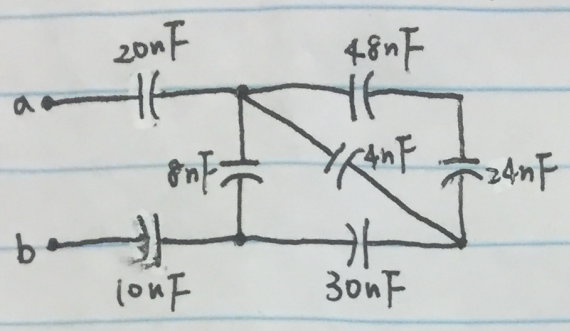
$50 \parallel 75 \parallel 30 = 15$

$15 + 15 = 30$

$30 \parallel 60 = 20$

$20 + 25 = 45\ \mu H$ #

Find the equivalent capacitance with respect to a, b



$$\frac{48 \cdot 24}{48+24} = 16$$

$$16+4 = 20$$

$$\frac{20 \cdot 30}{20+30} = 12$$

$$12+8 = 20$$

$$1/\left(\frac{1}{20}+\frac{1}{10}+\frac{1}{20}\right) = 5\,nF \ \#$$