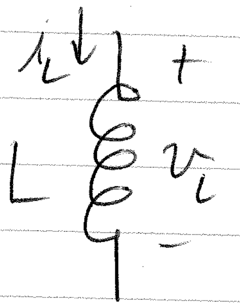
Inductors – the other energy storing element



IV:

$$v_L = L\frac{di_L}{dt}$$

L = inductance

Units: 1 Henry (H) $= \frac{1\,V\cdot s}{1\,A}$

Invert:

$$v_L = L\frac{di_L}{dt}$$

$$\int v_L\,dt = \int L\,di_L$$

$$\int_0^t v_L(x)\,dx = \int_{i_L(0)}^{i_L(t)} L\,di_L$$

$$= L\left[i_L(t) - i_L(0)\right]$$

$$L\,i_L(t) = L\,i_L(0) + \int_0^t v_L(x)\,dx$$

$$\underset{\substack{\uparrow\\ \text{Final}\\ \text{Condition}}}{i_L(t)} = \underset{\substack{\uparrow\\ \text{Initial}\\ \text{Condition}\\ (t=0)}}{i_L(0)} + \underbrace{\frac{1}{L}\int_0^t v_L(x)\,dx}_{\substack{\text{change from}\\ t=0 \text{ to } t=t}}$$

or $\quad i_L(t) = i_L(0) + \frac{1}{L}\int_0^t v_L(t')\,dt'$

or $\quad i_L(t) = i_L(0) + \frac{1}{L}\int_0^t v_L(t)\,dt$

Again, mathematicians cringe, but we know.

Power + Energy

$$p_L(t) = i_L(t)\, v_L(t)$$

$$= i_L(t)\, L \frac{di_L}{dt}$$

$$= L\, i_L(t) \frac{di_L}{dt}$$

$$p_L(t) = \frac{d i_L}{dt}\left(\frac{1}{2} L\, i_L^2(t)\right)$$

So $w_L(t) = \frac{1}{2} L\, i_L^2(t)$ is the energy stored (in the magnetic field)

always positive

and $p_L(t)$ is the rate at which energy is stored(+) or returned(−) to the system.

Summary 1. $v_L = 0$ if i_L is a constant. L is a short ckt to DC.

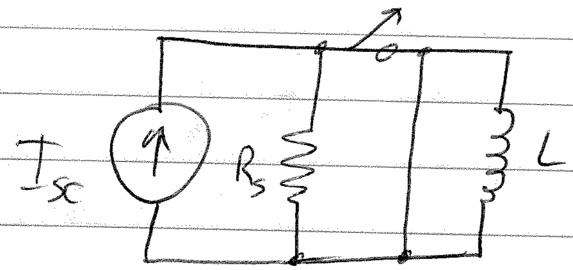
2. ~~Current~~ i_L is continuous, or cannot change instantaneously, $i_L(0^-) = i_L(0^+)$.

3) Stores energy.

Examples + Exercises (6-6 thru 6-8) in text.

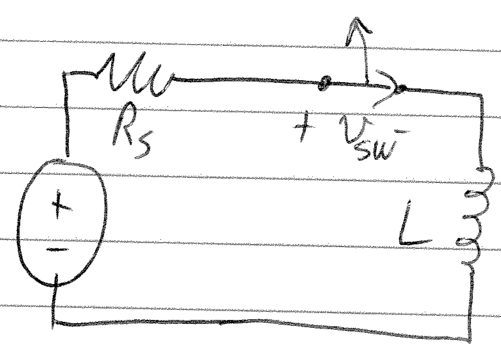
~~Read + Do examples & Exercises 6-13 & 6-14 & 6-15.~~

L's cannot store energy for as long as C's can because they require a current to flow:



No matter how good you try to make it, there will be <u>some</u> resistance and it will dissipate the energy.

L's can generate big voltages when you try to turn them off:



An electric motor is an inductor say in a <u>fan</u>.

Try turning this off suddenly and you can get <u>big</u> voltages across the switch, so big that sparks jump.