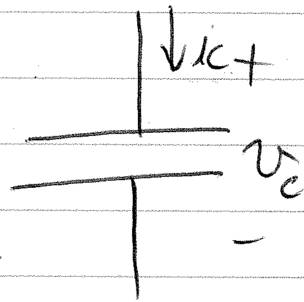
We need to move on to see:

Capacitors (Section 6-1)

Symbol



C ← Capacitance

~~Eqn~~ I-V relation:

$$\boxed{i_c = C\frac{dv_c}{dt}}$$

$$\text{Units of } C = \frac{\text{Amps}}{\text{Volts/sec}} = \text{Farad}$$

$$= \frac{A \cdot s}{V}$$

$$C = \frac{\text{Coulombs}}{V}$$

1 F is pretty big, so we usually use

μF, nF, pF

Invert I-V: $\int i_c\, dt = C\, dv_c$

$$\int_0^t i_c(x)\,dx = C\int_{v_c(t_0)}^{v_c(t)} dv_c$$

$$\int_0^t i_c(x)\,dx = C\left[v_c(t) - v_c(t_0)\right]$$

or $\quad v_c(t_0) = v_c(0) + \frac{1}{C}\int_0^t i_c(x)\,dx$

or $\quad v_c(t_0) = v_c(0) + \frac{1}{C}\int_0^t i_c(t')\,dt'$

or $\quad v_c(t_0) = v_c(0) + \frac{1}{C}\int_0^t i_c(t)\,dt \quad$ Mathematician crime, but we know.

Power + Energy

$$p_c(t) = i_c(t)\, v_c(t)$$

$$= C \frac{dv_c}{dt} v_c(t)$$

$$p_c(t) = C\, v_c \frac{dv_c}{dt}$$

$$= C \frac{d}{dt}\left(\frac{1}{2} v_c^2\right)$$

$$p_c(t) = \frac{d}{dt}\left(\frac{1}{2} C v^2\right)$$

So, we interpret this to say that

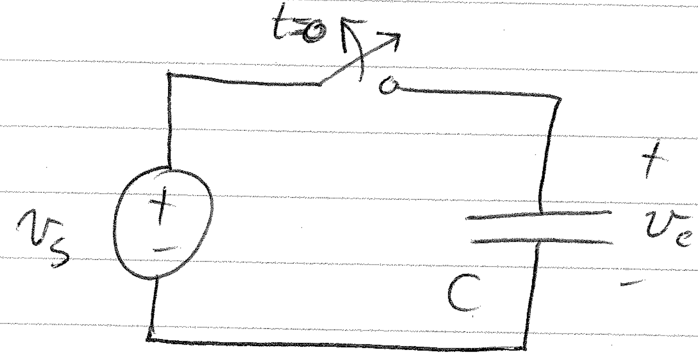
$w_c(t) = \frac{1}{2} C v^2(t)$ is the energy stored in the capacitor

and $p_c(t) = \frac{d}{dt} w_c(t)$ is the rate at which energy is added to or removed from the capacitor, or the power "dissipated" (or removed from the ckt and stored) by the capacitor.

Summary
1.) $i_c = 0$ unless v_c is changing. Capacitor looks like an open ckt at DC.
2.) v_c is continuous, i.e., cannot change instantaneously.
3.) Absorbs ~~energy~~ power when storing energy, sources ~~energy~~ power when delivering stored energy back to ckt.

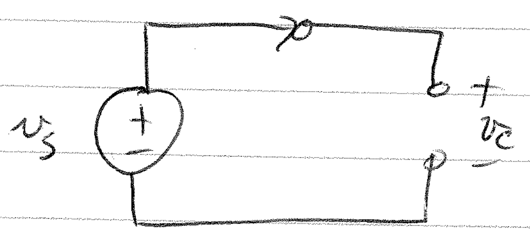
Examples + Exercises in text

A capacitor charged to some voltage and then disconnected:



~~$v_c(0^-)$~~

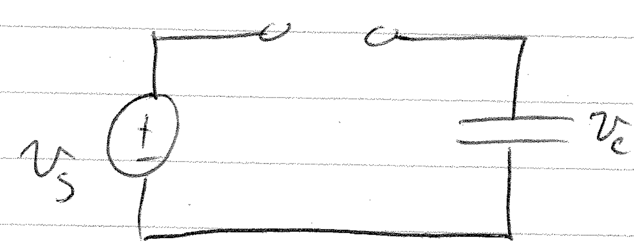
For $t<0$ the ~~capacitor~~ ckt is DC:



$$\underline{v_c = v_s}$$

$$\lim_{t \to 0^-} v_c = v_s$$

For $t>0$ there is no place for current to flow:



continuous

$$v_c(0^+) = v_c(0^-) = v_s$$

Since $i_c(t>0) = 0 = C \frac{dv_c}{dt}(t>0)$

this means $\frac{dv_c}{dt} = 0$ for $t>0$

or v_c is constant.

So a capacitor can "hold a charge". Old Vacuum tube TV's + radios had high voltage sources in them, with capacitors. There are occassional reports of kids finding radios or TVs in attics and opening them up and being shocked or even killed by stored charges from 50 or more years ago!