2)

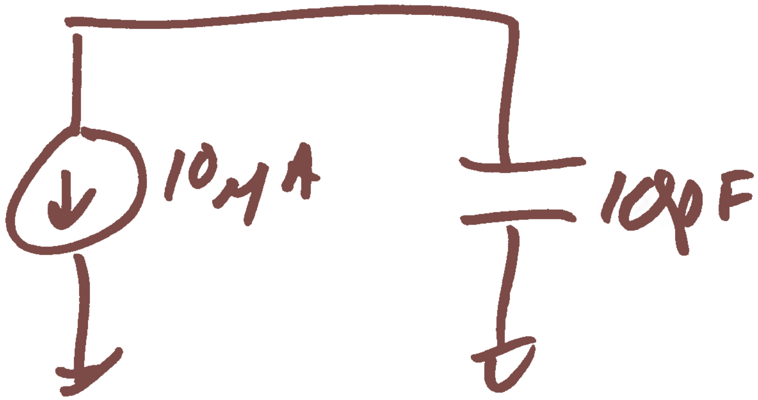
EE 220 Circuits 1

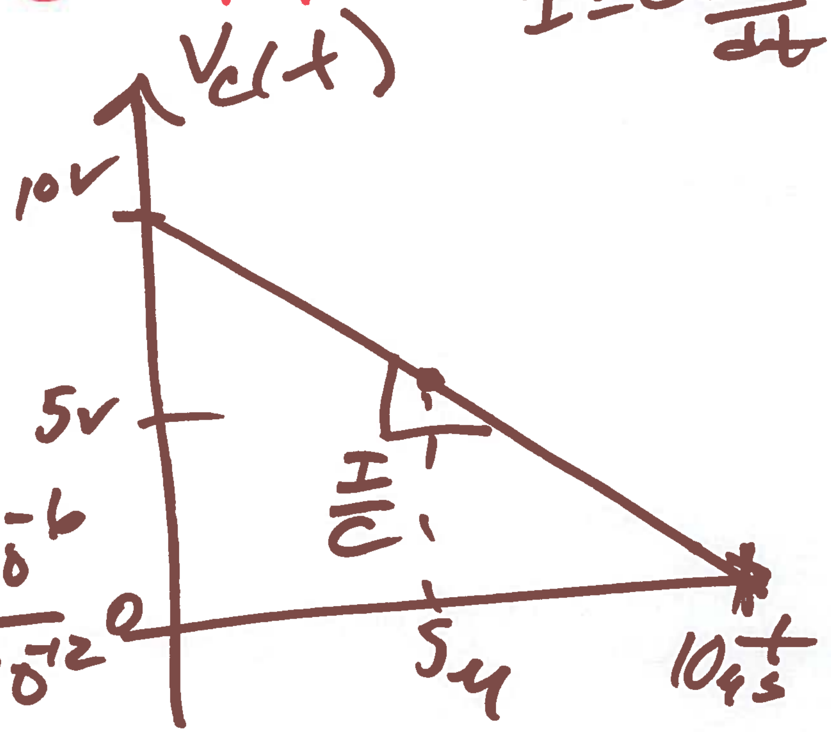
Lecture 19

$$I = 10pF \cdot \frac{4V}{4\mu s} = \frac{10 \cdot 10^{-12} \cdot 10^{6}}{10^{-6} \cdot 10^{6}}$$

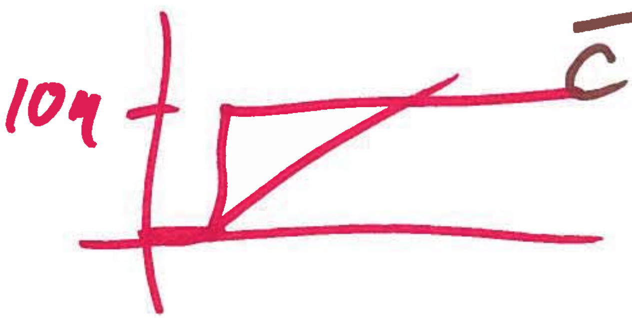
$$// \quad 10\mu A$$

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

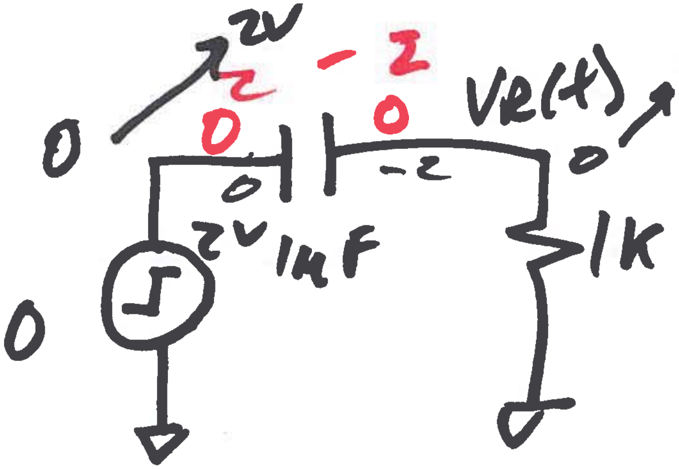




$$\frac{I}{C} = \frac{10\mu}{10p} = \frac{10^{-6}}{10^{-12}} = \frac{1V}{\mu s}$$



1)

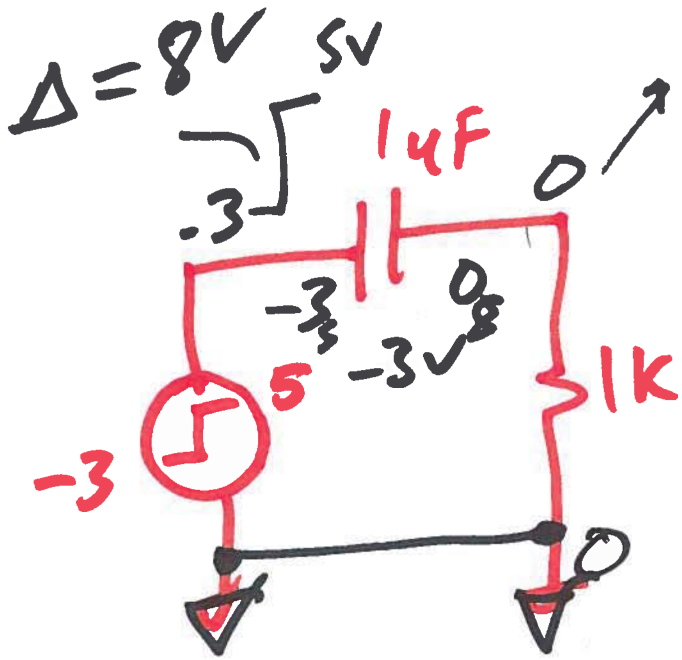


DC → CAP = open

FAST edge → CAP = short

$$V_R(t) = 0 + (2 - 0)e^{-t/RC}$$

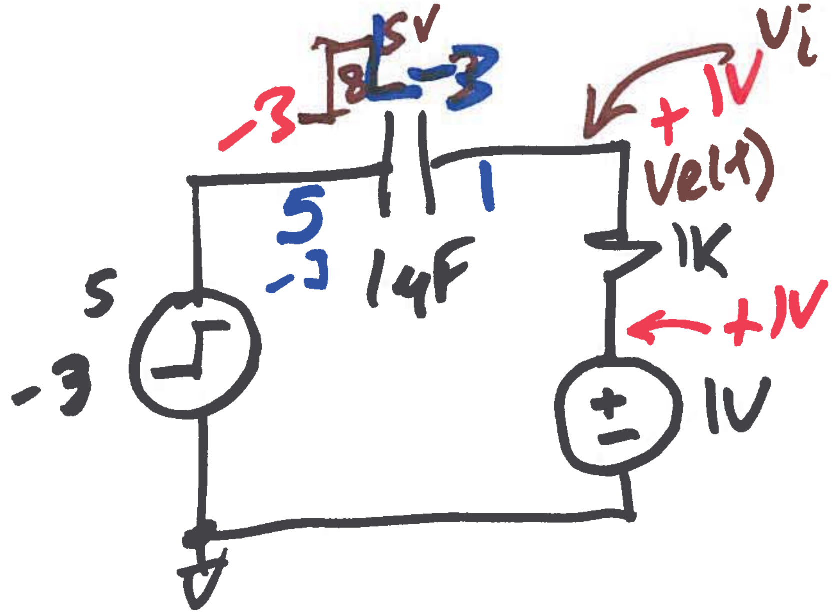
$$= 2e^{-t/RC}$$

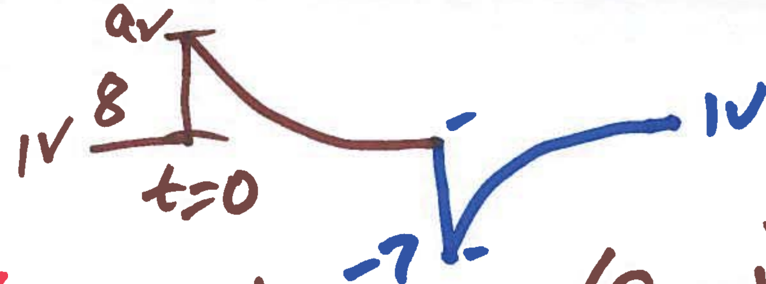


$8e^{-t/RC}$

$5 - 8 = -3$

$-3 - 0 = -3$



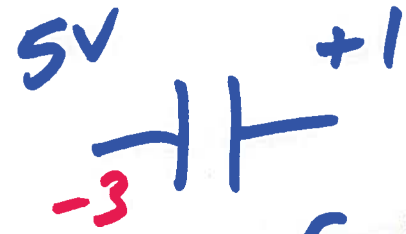


$$V_R(t) = 1 + (9-1)e^{-t/RC}$$

$$V_c = -3-1 = -4V$$

$$-4 = 5 - V_i$$

$$V_i = 9V$$



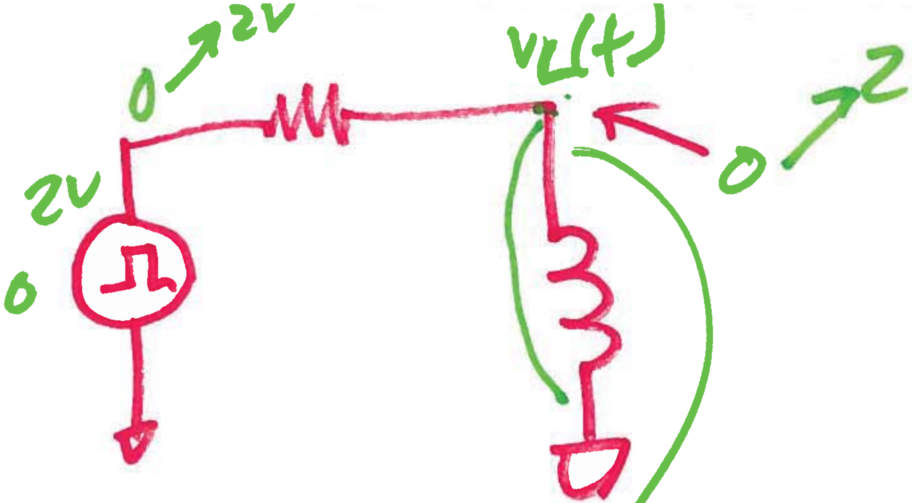
$$V_c = 5-1 = 4$$

$$4 = -3 - V_i$$

$$V_i = -7$$

$$V_c = 5-1 = 4V$$

$$4V = -3 - V_i \Rightarrow V_i = -7V$$



Inductor

DC → short

AC → open

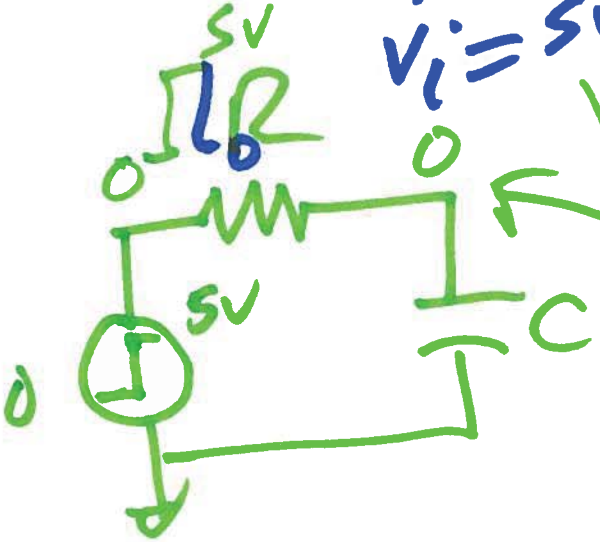
↑ fast edge

$$v_L(t) = \overset{v_f}{0} + (\overset{v_i}{2} - \overset{v_f}{0})e^{-t/(L/R)}$$

$$= 2e^{-t/(L/R)}$$

$V_f = 0$

$V_i = 5V$



$V_i = 0$

$V_f = 5V$

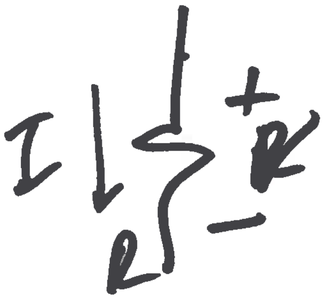
$$V_c(t) = 5 + (0-5)e^{-t/RC}$$

$$= 5(1 - e^{-t/RC})$$

$$v_o(t) = 0 + (5-0)e^{-t/RC}$$

$$= 5e^{-t/RC}$$

Energy Storage

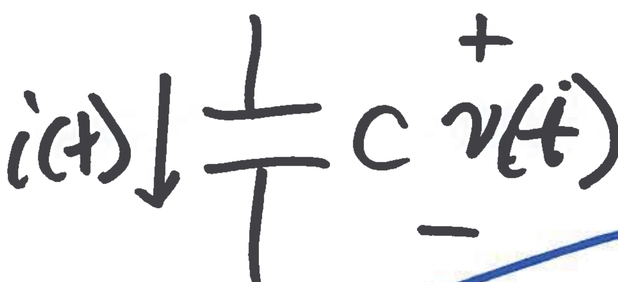


$p = V \cdot I = \frac{V^2}{R} = I^2 R$, in caps & induct

No power diss. in an inductor & cap.

CAP.

instantaneous power



$$p(t) = v(t) \cdot i(t)$$

$$i(t) = C \cdot \frac{dv(t)}{dt}$$

$$\mathcal{E} = \int p(t)\,dt = \int C \cdot v(t) \cdot \frac{dv(t)}{dt}$$

energy, Joules

Energy stored $= \int_0^t \mathcal{E}\,dt = C \int_0^{v(final)} v(t) \cdot dv(t)$

$$\mathcal{E} = \int p(t)\cdot dt = C \cdot \int_0^{V_{final}} v(t)\cdot dv(t)$$

$$i(t) = C\frac{dv(t)}{dt}$$

$$p(t) = v(t)\cdot i(t) = C\cdot v(t)\frac{dv(t)}{dt}$$

$$\mathcal{E} = \int p(t)\cdot dt = C\int_0^{V_{final}} v(t)\cdot dv(t)$$

$$\boxed{\mathcal{E} = \frac{1}{2}CV^2}$$

Energy stored on a cap

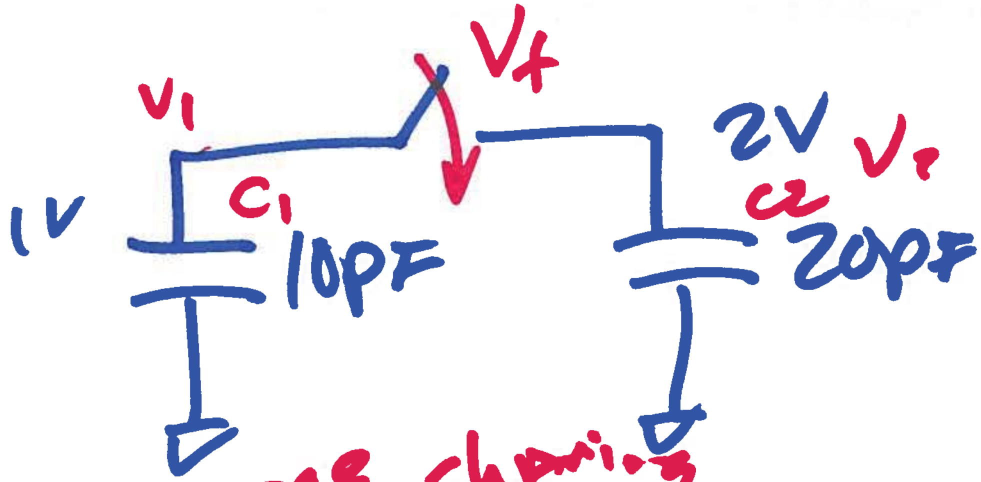
$$p(t) = v(t) \cdot i(t), \quad v(t) = L \cdot \frac{di(t)}{dt}$$

$$\mathcal{E} = \int p(t) \cdot dt = \int_0^I L \cdot i(t) \cdot \frac{di(t)}{dt}$$

energy stored in inductor

$$\boxed{\mathcal{E} = \frac{1}{2} L I^2}$$

$$\mathcal{E} = \int p(t) \cdot dt = \int_0^I L \cdot i(t) \cdot \frac{di(t)}{\cancel{dt}} \cdot \cancel{dt}$$



Charge sharing

$\frac{1}{2} \cdot 10p \cdot 1^2$ $\qquad$ $\frac{1}{2} \cdot 20pF \cdot 2^2$

5pJ $\qquad$ 40pJ

45pJ stored on the two caps

$$\mathcal{E} = \frac{1}{2} C V^2$$

$$CV = Q$$

$$30p \cdot V_f = C_1 \cdot V_1 + C_2 \cdot V_2$$

$$= 10pC + 40pC$$

$$V_f = \frac{50}{30}$$

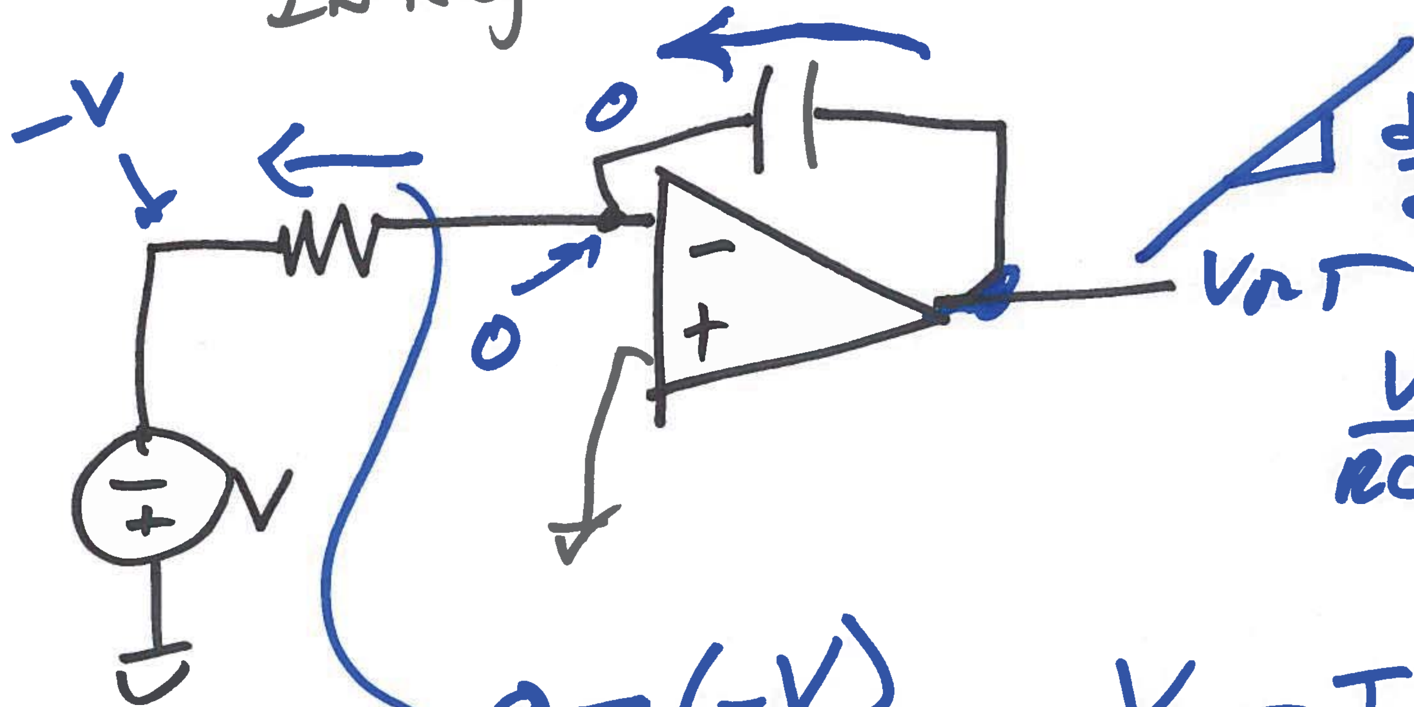
$$V_f = \underline{\underline{1.66V}}$$

After switch closes

$$\mathcal{E} = \frac{1}{2} \cdot 30pF \cdot 1.66V^2$$

$$= 41.3pJ$$

Integration



$$\frac{dV_c}{dT} = \frac{I}{C}$$

$$\frac{V}{RC}$$

$$\frac{0-(-V)}{R} = \frac{V}{R} = I_{constant}$$