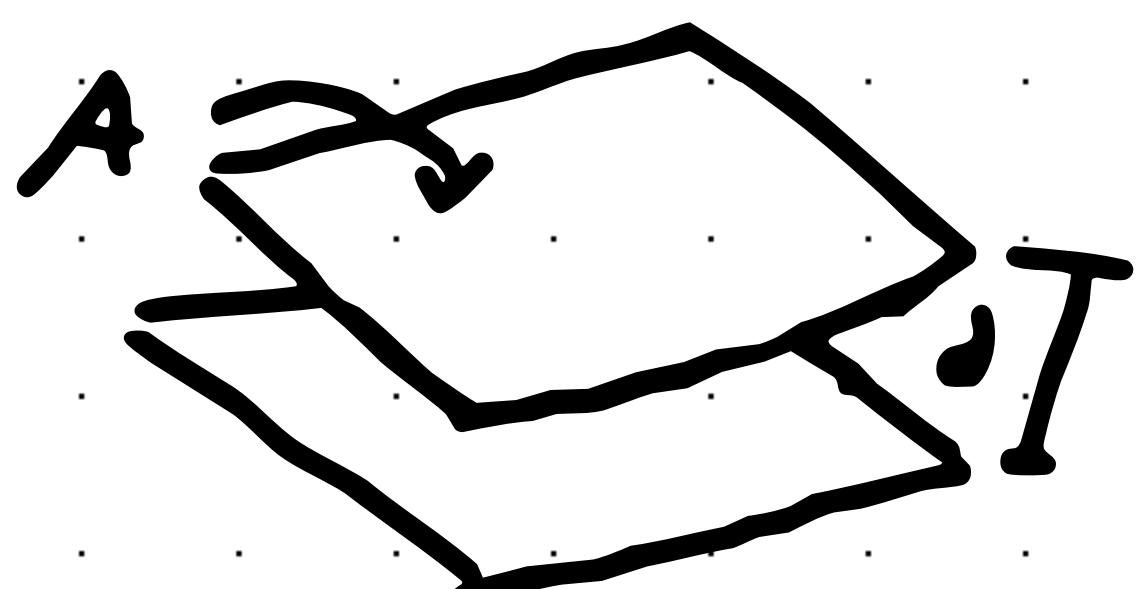


CAPACITORS



$$\text{Capacitance} = C = \frac{q}{v}$$

→ Charge
→ Voltage

(ϵ_r) or (F_{air})

F

→ Permeability of free space =

$$8.84 \times 10^{-12} \text{ F/m}$$

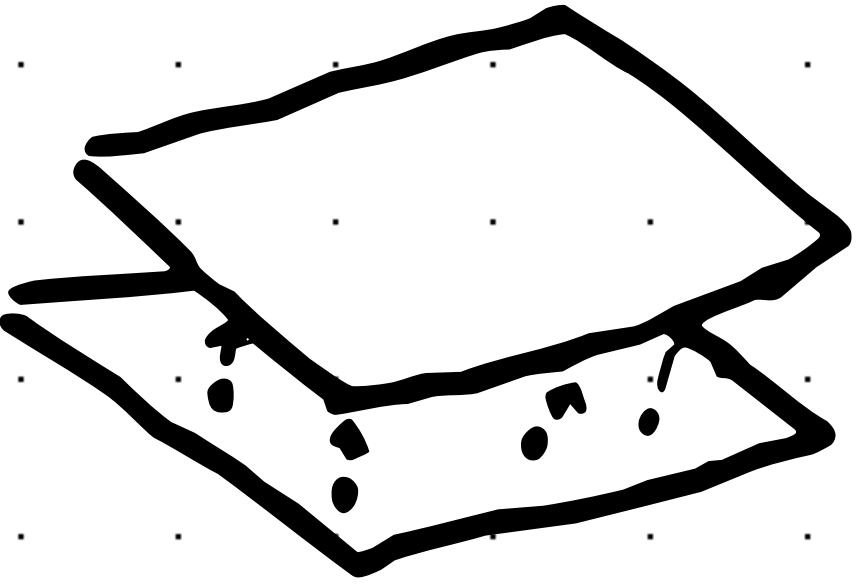
A = Plate Area

d = Distance between two plates

$$i = \frac{dq}{dt} = \frac{d(CV)}{dt} = C \frac{dv}{dt}$$

Now, we are assuming that the Capacitance (C) is constant. This is not true in reality, because the plate distance can change, or the plate media assume C is constant.

With Capacitors, Current Leads Voltage

- This is because, in a capacitor, you have two plates that are separated. by 90°!
- 
- To create a potential difference in between the two plates, you require a lot of current!
- In other words, in order to create voltage, you NEED current first!

EQUATIONS USED BY CAPACITORS

$$V_{C(t)} = \frac{1}{C} \int_{t_0}^{t} i_{C(t)} dt + V_{C(t_0)}$$

Voltage

$$i_C = \frac{dQ}{dt} = \frac{d(CV)}{dt} = C \frac{dV}{dt}$$

Current

$$P = V_{C(t)} i_{C(t)} = C V_{C(t)} \frac{dV_{C(t)}}{dt}$$

Power

$$W \approx \frac{1}{2} CV^2$$

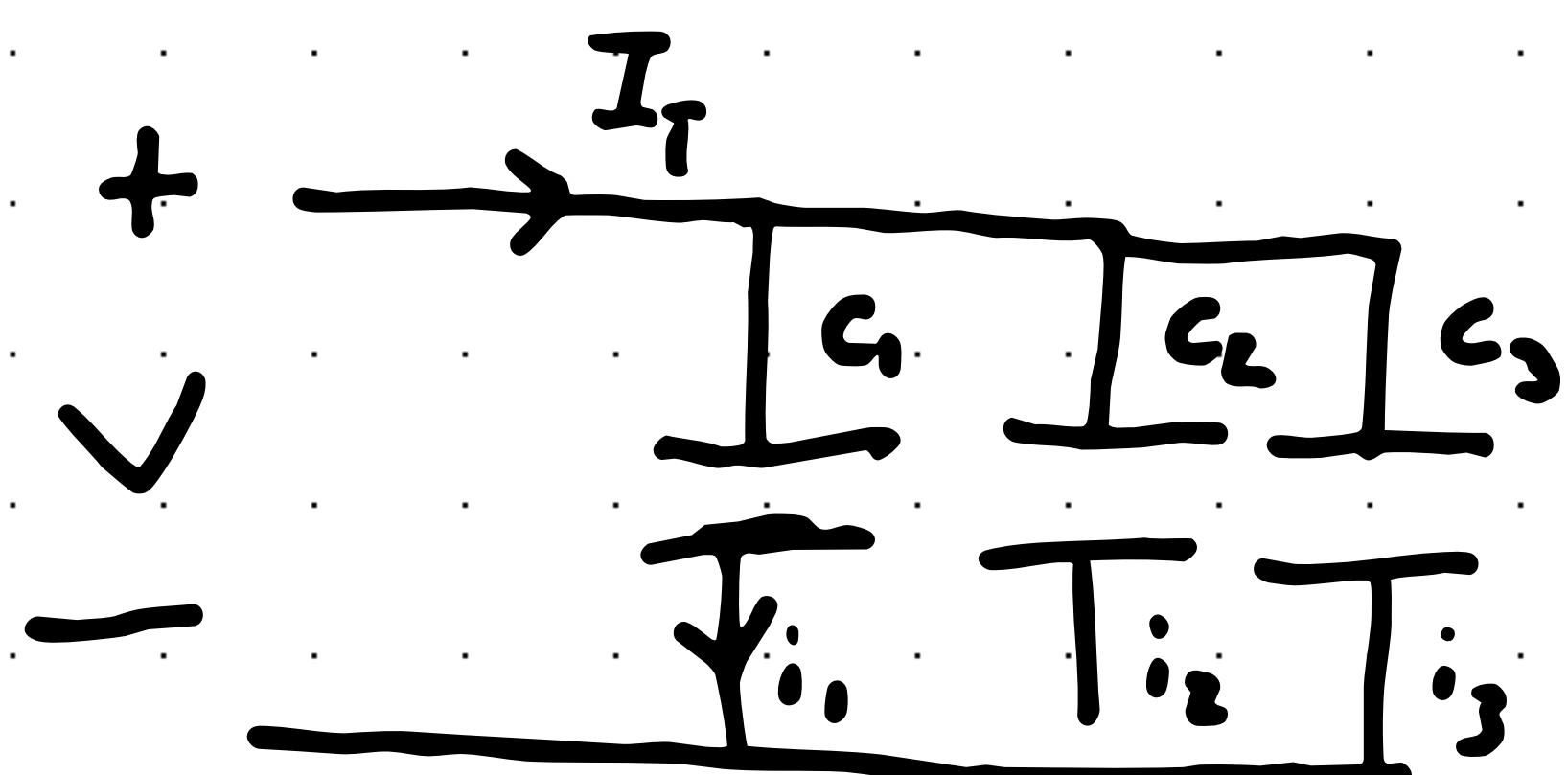
Energy "stored" in capacitor,
or energy discharged by capacitor

Capacitors in Series



$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Capacitors in Parallel



$$C_T = C_1 + C_2 + C_3$$

For DC Circuits

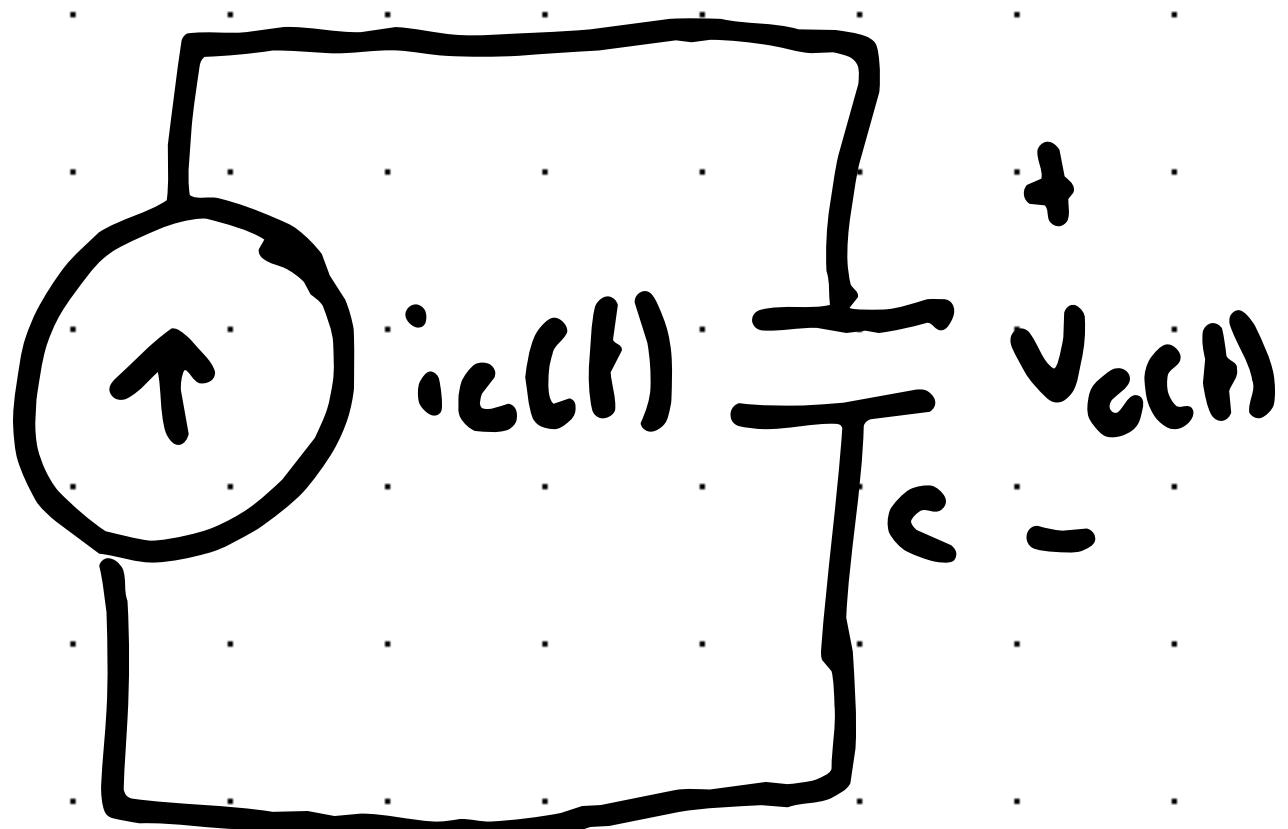
$$\text{Since } i = C \frac{dv}{dt}$$

In DC, the Capacitor appears to be an open circuit

This occurs while the Capacitor is Charging. This is called the Transient State, or the Transient period. It is not a steady state. While it "spools" up, there is a period where things are unknown, or unpredictable. It's like when you first get up in the morning. Or, like an old elevator first moves up, right?

Ex

$$i_c(t) = \begin{cases} 0 & t < 0 \\ 5000t & 0 < t < 20 \mu s \\ 0.2 - 5000t & 20 \mu s < t < 40 \mu s \\ 0 & t > 40 \mu s \end{cases}$$

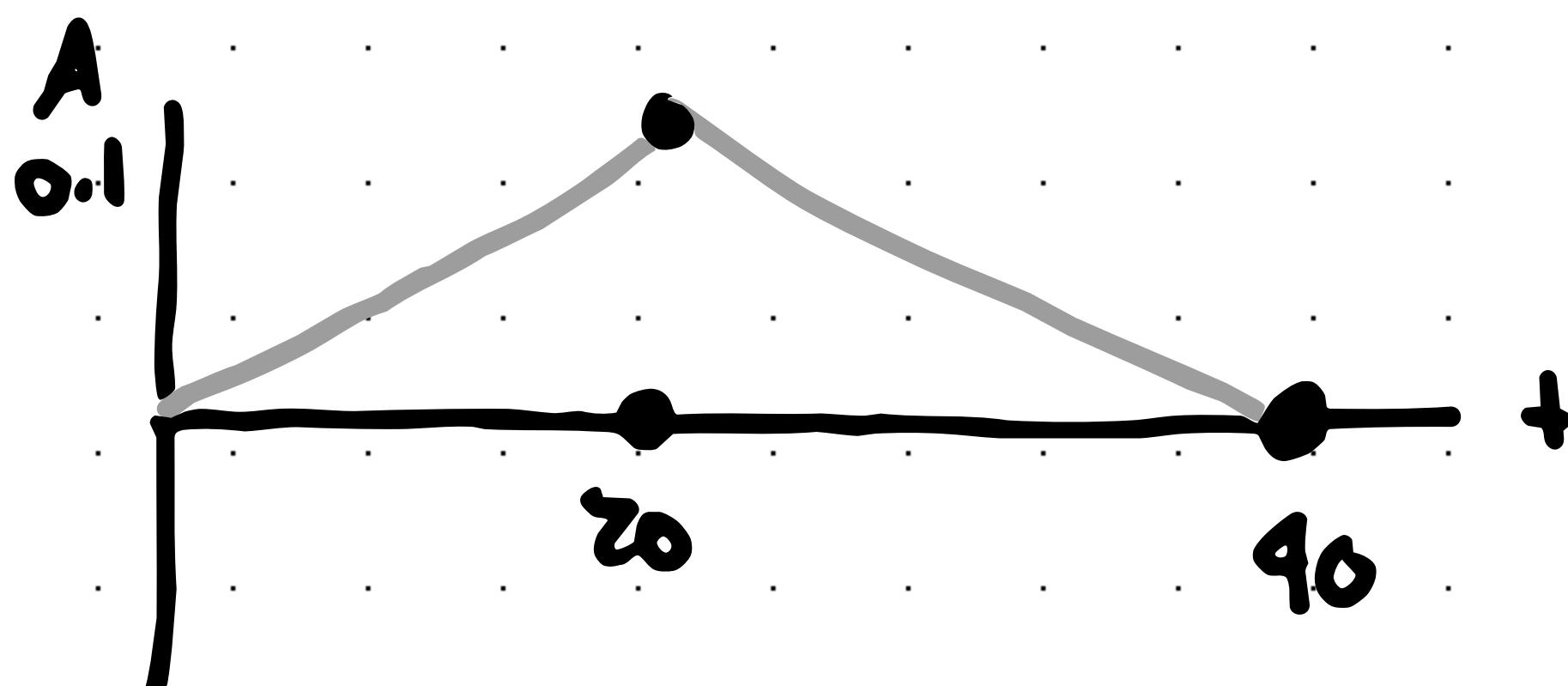


$$C = 0.2 \text{ } \mu\text{F}$$

$$V_C(0) = 0$$

Calculate $V_C(t)$, $P(t)$, $W(t)$ and Sketch

Sol



$$V(t) = \frac{1}{C} \int i_c(t) dt + V_0, \quad 0 < t < 20 \mu s$$

$$V(t) = \frac{10^6}{0.2} \int 5000t dt + V_{C(0)}$$

$$V(t) = \frac{10^6}{0.2} \left[5000t^2 \Big|_0^+ \right] = 12.5 \times 10^9 t^2$$

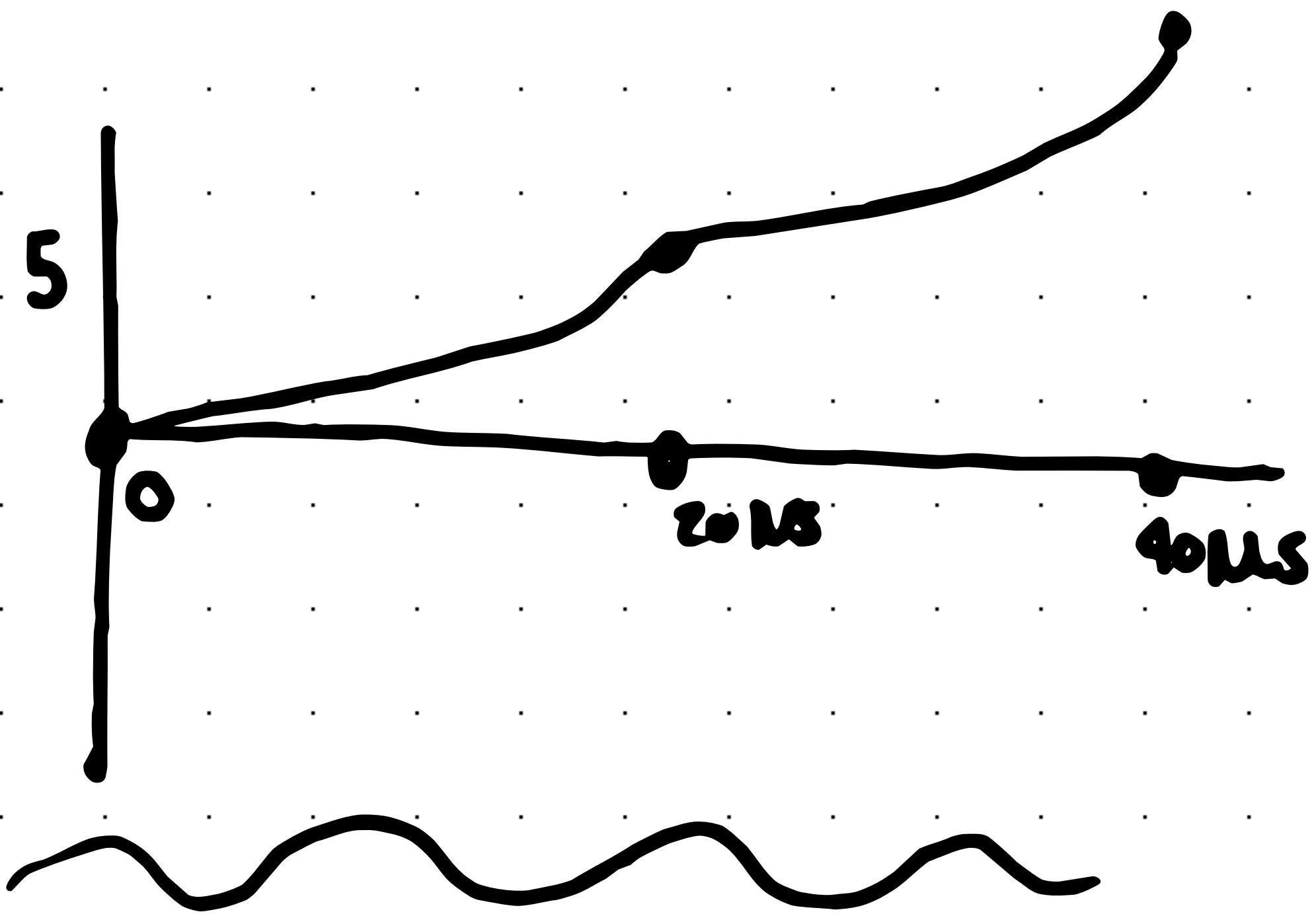
at $t = 20 \mu s \rightarrow V_{C(t)} = 5V$

$20 \mu s < t < 40 \mu s$

$$V_C(t) = \frac{10^6}{0.2} \int_{20}^t (0.2 - 5000t) dt + V_C(t=20 \mu s)$$

5

$$V_C(t) = 10^6 t - 12.5 \times 10^9 t^2 - 10$$



$$P = V_C(t) i_C(t)$$

$$W = \int P dt = \frac{1}{2} C V^2$$

$0 < t < 20 \mu s$

$$P_C(t) = (5000t)(12.5 \times 10^9 t^2) = 62.5 \times 10^{12} t^3$$

$$W = \int (62.5 \times 10^{12} t^3) dt$$

$$= 15.625 \times 10^{12} t^4$$

$20 \leq t < 40 \text{ us}$

$$P(t) = (0.2 - 5000t)(10^6 + 12.5 \times 10^9 t^2 - 10) =$$
$$= 62.5 \times 10^{12} t^3 - 7.5 \times 10^9 t^2 + 2.5 \times 10^5 t - 2$$

$$W(t) = 15.625 \times 10^{12} t^4 - 2.5 \times 10^9 t^3$$
$$+ 0.125 \times 10^6 t^2 - 2 \times 10^{-11} t$$

