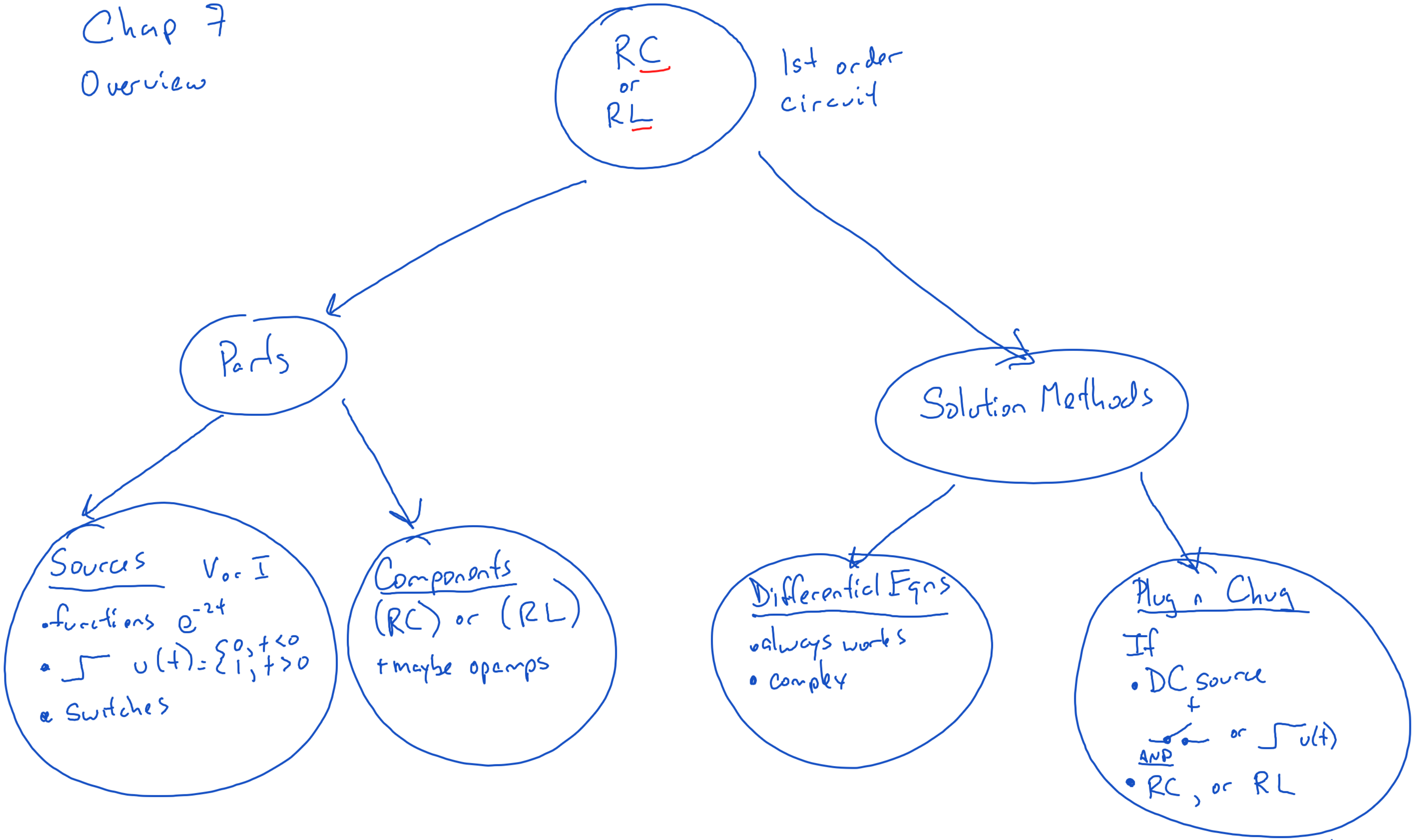
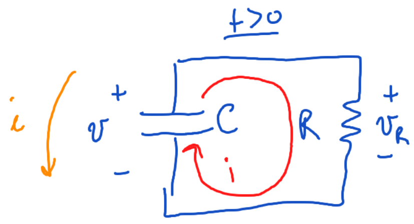
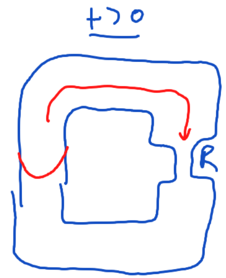
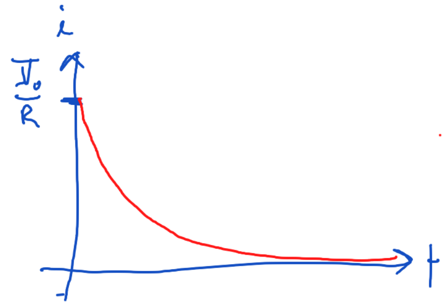
Chap 7 Overview



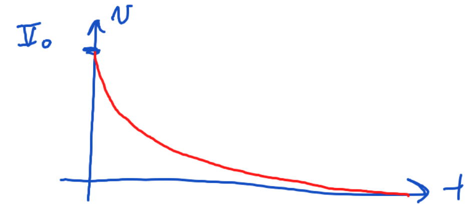
RC natural response







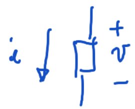
$V_0 = v(t=0)$



① Find DE in v

→ • $v_R = iR$ ←

→ • $i = C v_c'$ ←



Passive

• KVL: $-v + v_R = 0$ ← geometry

$-v + iR = 0$ R

$-v + -Cv'R = 0$ C

$-v'RC - v = 0$

$$v' + \frac{1}{RC} v = 0, \quad v(0) = V_0$$

② Solve DE

• natural part $s + \frac{1}{RC} = 0$, $s = -\frac{1}{RC}$ } $v_{nat}(t) = k e^{-\frac{1}{RC}t}$

• forced part 0

• total part $v(t) = k e^{-\frac{1}{RC}t}$

$v(0) = V_0 = k$

total solution: $v(t) = V_0 e^{-\frac{1}{RC}t} = V_0 e^{-\frac{t}{\tau}}$ where $\tau = RC$

RC "time constant"

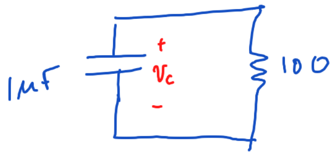
units seconds

Plug-n-chug!

τ

- very quick (but approx) understanding of time to discharge
- $v(t) = V_0 e^{-\frac{t}{\tau}}$, $\tau = RC$

Ex



$v_c(0) = 90V$

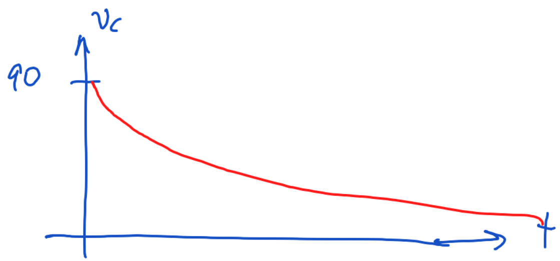
$v_c(t) = 90 e^{-\frac{t}{\tau}}$, $\tau = (1\mu)(100) = 100\mu s$

$\frac{1}{100\mu} = \frac{1}{100} \cdot \frac{1}{\mu}$

$= (0.01) M$

$= 10k$

G
M
k
1
m
μ
n
p



Exact

when is it $\frac{1}{2}$ discharged? | $45 = 90 e^{-\frac{t}{100\mu}}$, $\ln(\ )\ \ln(\ )$ $\frac{1}{2} = e^{-\frac{t}{10000}}$, $\ln(\frac{1}{2}) = -\frac{t}{1000}$

when is it 99% discharged | $0.9 = 90 e^{-\frac{t}{100\mu}}$ . . .

τ

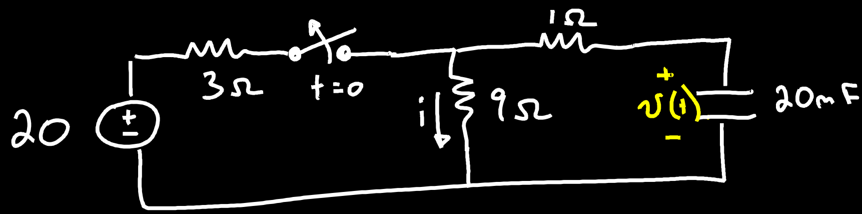
"little less than τ"

$100\mu s$

$e^{-1} \approx 0.35$

"99% discharged at 5τ" $500\mu s$

First Order Problem



Find i for all time

① $V_0 = v_c(t \le 0)$; t<0 = $\boxed{15\,V}$

② τ

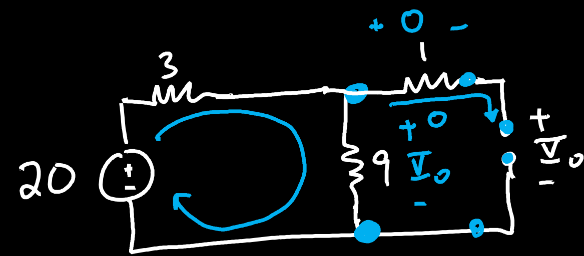
③ V_∞

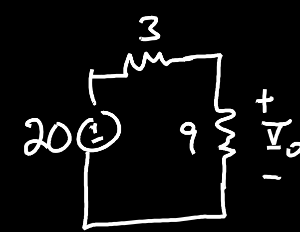
④ $v(t) = V_\infty + (V_0 - V_\infty)e^{-t/\tau}$

⑤ $i(t)$

⑥ All time

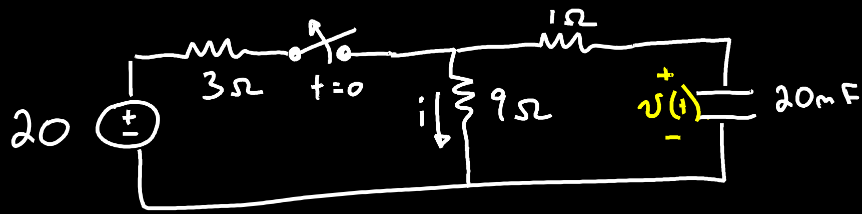
t < 0





$$V_0 = 20\frac{9}{3+9} = 20\cdot\frac{9}{12} = \overset{5}{\cancel{20}}\,\frac{3}{\cancel{4}_1} = 15\,V$$

First Order Problem



Find i for all time

① $V_o = v_c(t \le 0)$: $t < 0$ $= \boxed{15V}$

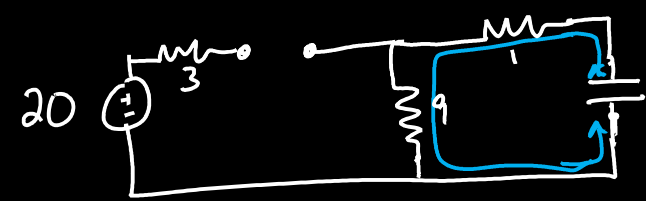
② τ : $0 < t < \infty$ $= \boxed{\frac{1}{5}s}$

③ V_∞

④ $v(t) = V_\infty + (V_o - V_\infty)e^{-t/\tau}$

⑤ $i(t)$

⑥ All time



$R_{eq} = 1 + 9 = 10\,\Omega$

$C = 20mF$

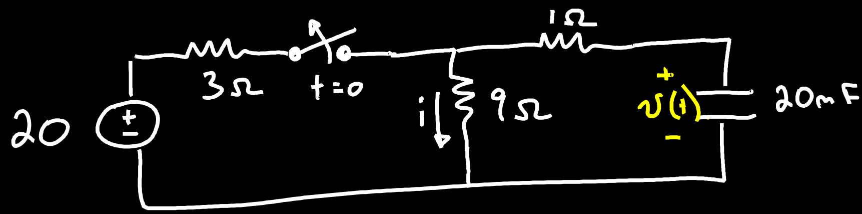
$\tau = RC$

$= (10)(20m)$

$= 200m$

$= \boxed{\frac{1}{5}s}$

First Order Problem



Find i for all time

① $V_0 = v_c(t \le 0)$: $t < 0$ = **15V**

② τ : $0 < t < \infty$ = **$\frac{1}{5}$ s**

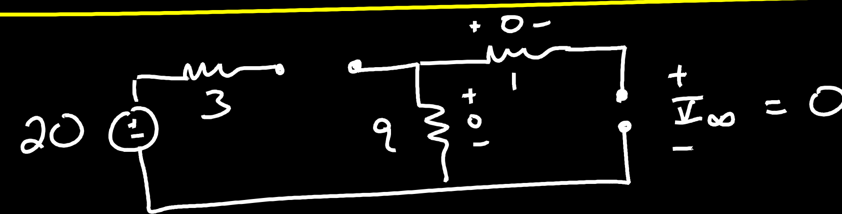
③ $V_\infty = v_c(t = \infty)$: $t = \infty$ = **0V**

④ $v(t) = V_\infty + (V_0 - V_\infty)\, e^{-t/\tau}$

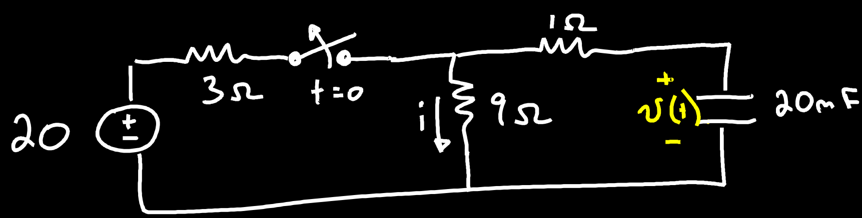
⑤ $i(t)$

⑥ All time

no switches
no cap, inductors
no v(t)



First Order Problem



Find i for all time

① $V_0 = v_c(t \le 0)$: $t<0$ $= \boxed{15\,V}$

② τ : $0<t<\infty$ $= \boxed{\frac{1}{5}\,s}$

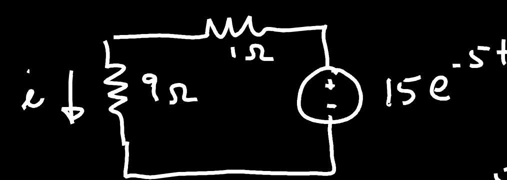
③ $V_\infty = v_c(t=\infty)$: $t=\infty$ $= \boxed{0\,V}$

④ $v_c(t) = V_\infty + (V_0 - V_\infty)e^{-t/\tau} = \begin{cases} 15, & t<0 \\ \boxed{15e^{-5t}\,V}, & t\ge 0 \end{cases}$

⑤ $i(t) = \begin{cases} \frac{5}{3}\,A, & t<0 \\ 1.5e^{-5t}\,A, & t\ge 0 \end{cases}$

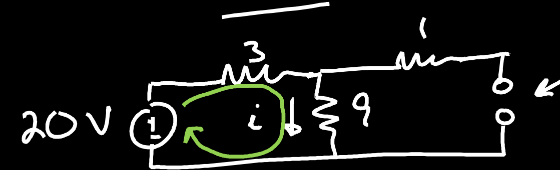
⑥ All time

$t>0$



$i(t) = \frac{v(t)}{R} = \frac{15e^{-5t}}{10} = \boxed{1.5e^{-5t}\,A}$

$t<0$



$i = \frac{20}{3+9}$

$= \frac{20}{12} = \frac{5}{3}$