SCHOOL OF ENGINEERING, ELECTRICAL AND ELECTRONIC ENGINEERING

NETWORKS 4_

Week B_

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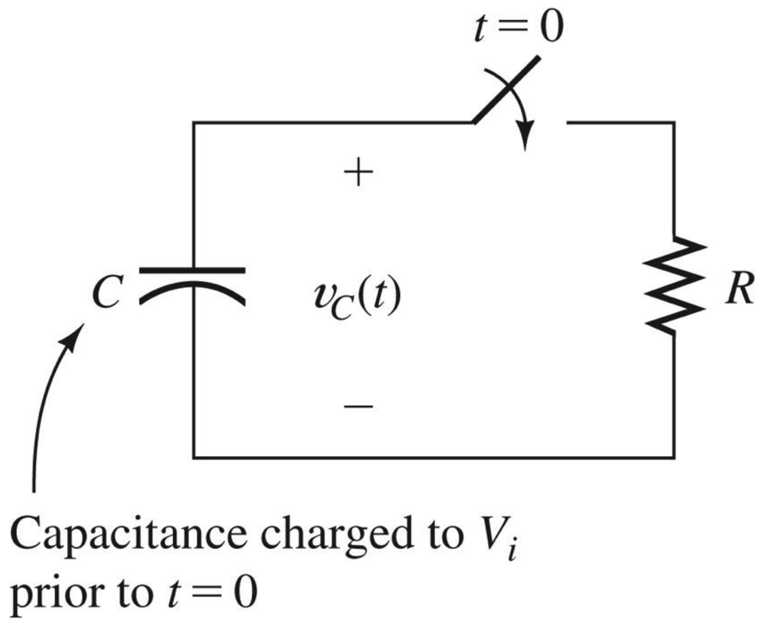
NET4 PROGRAM BY WEEK

1. 1st order RC networks – discharging – DC source
2. 1st order RC networks – charging – DC source
3. RL networks – Steady-state DC
4. RL networks – Switched DC source
5. RC & RL networks – complementary solution
6. <spare week>
7. Exam Wrapup

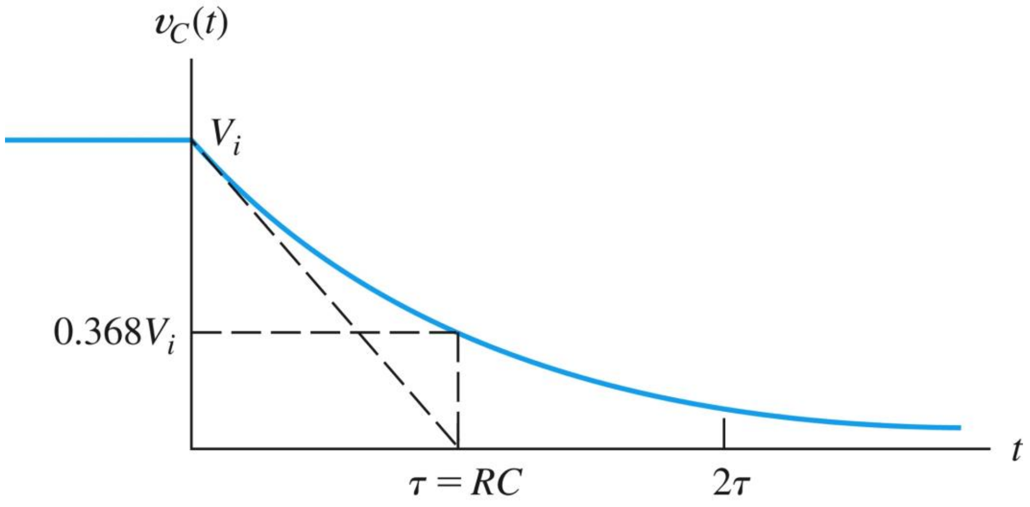
WEEK A: CAPACITOR & INDUCTOR

	Capacitor	Inductor
Voltage	$v = \frac{1}{C}\int i(t)dt$	$v = L\frac{di}{dt}$
Current	$i = C\frac{dv}{dt}$	$i = \frac{1}{L}\int v(t)dt$
Power	$P(t) = v(t) \cdot i(t)$	
Energy	$W(t) = \frac{1}{2}Cv^2(t)$	$W(t) = \frac{1}{2}Li^2(t)$
Energy stored in:	Electric field	Magnetic field

WEEK A: DISCHARGING A CAPACITOR



$$RC\frac{dv_C(t)}{dt} + v_C(t) = 0$$



$$v_C(t) = V_i e^{-t/RC}$$

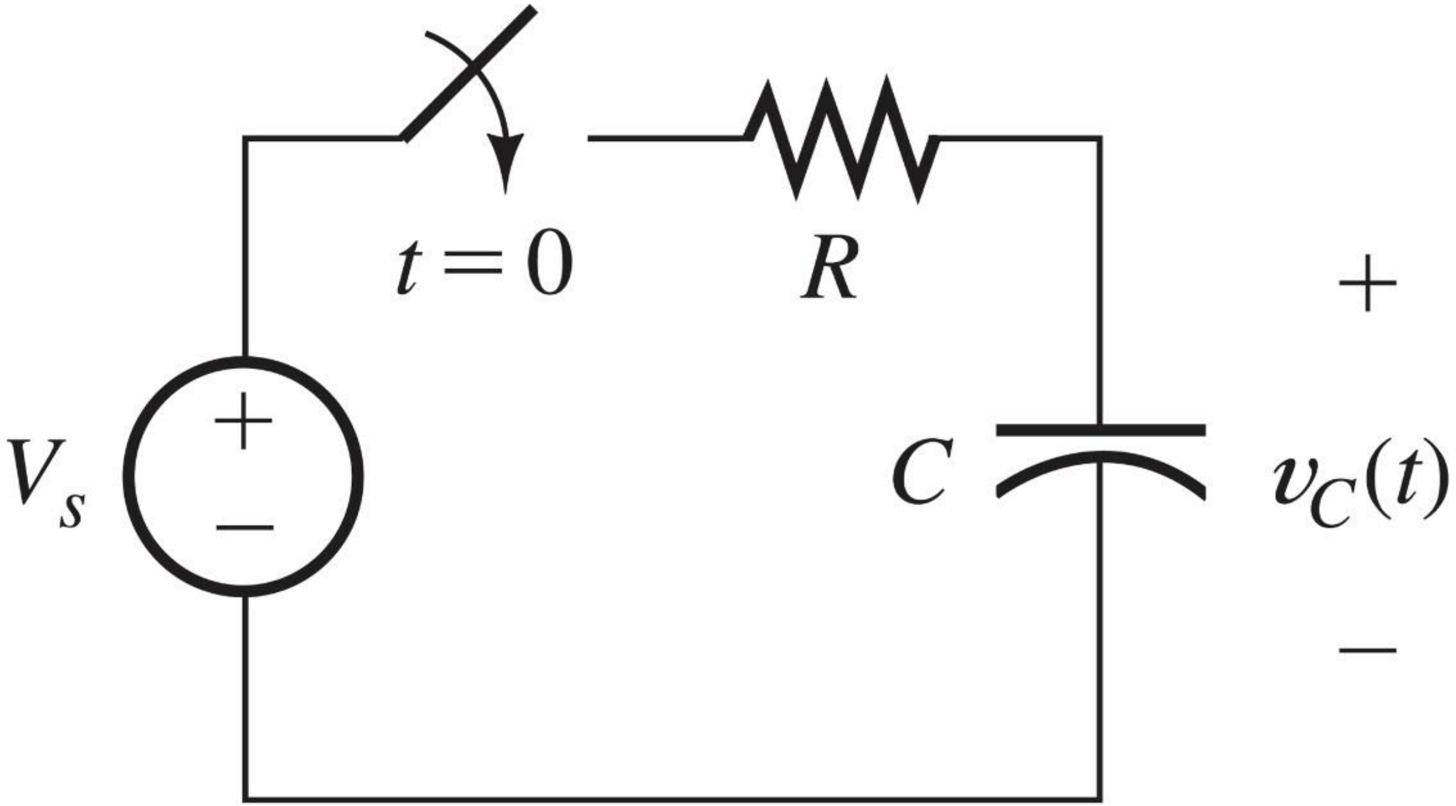
$$\tau = RC$$

THIS WEEK

1st order networks with a fixed DC source

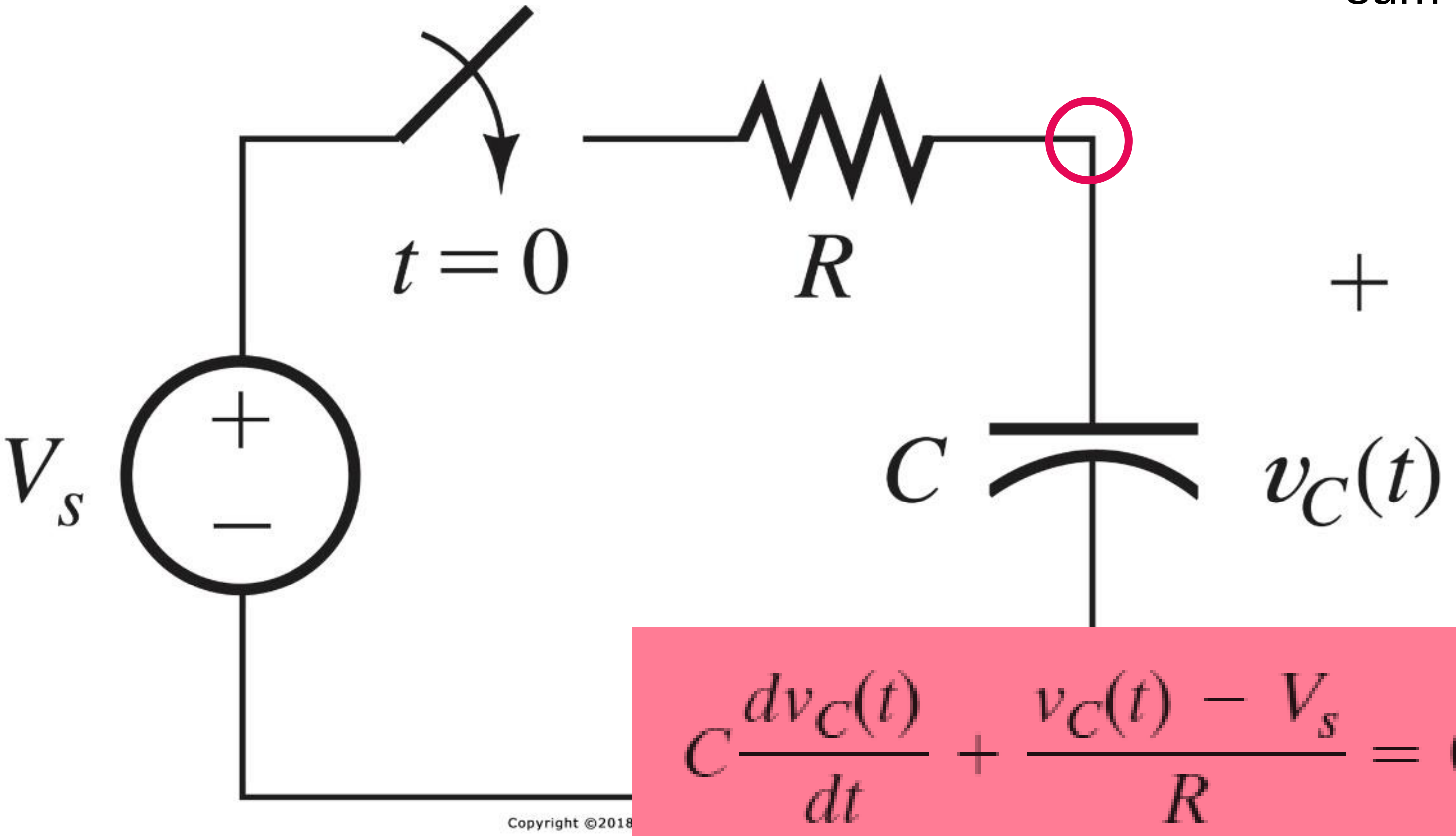
- Charging a capacitor

CHARGING A CAPACITOR



CHARGING A CAPACITOR: KCL

KCL:
- sum of currents = 0



Capacitor
$v = \frac{1}{C}\int i(t)dt$
$i = C\frac{dv}{dt}$
$P(t) =$

$$C\frac{dv_C(t)}{dt} + \frac{v_C(t) - V_s}{R} = 0 \qquad (4.10)$$

CHARGING A CAPACITOR: KCL

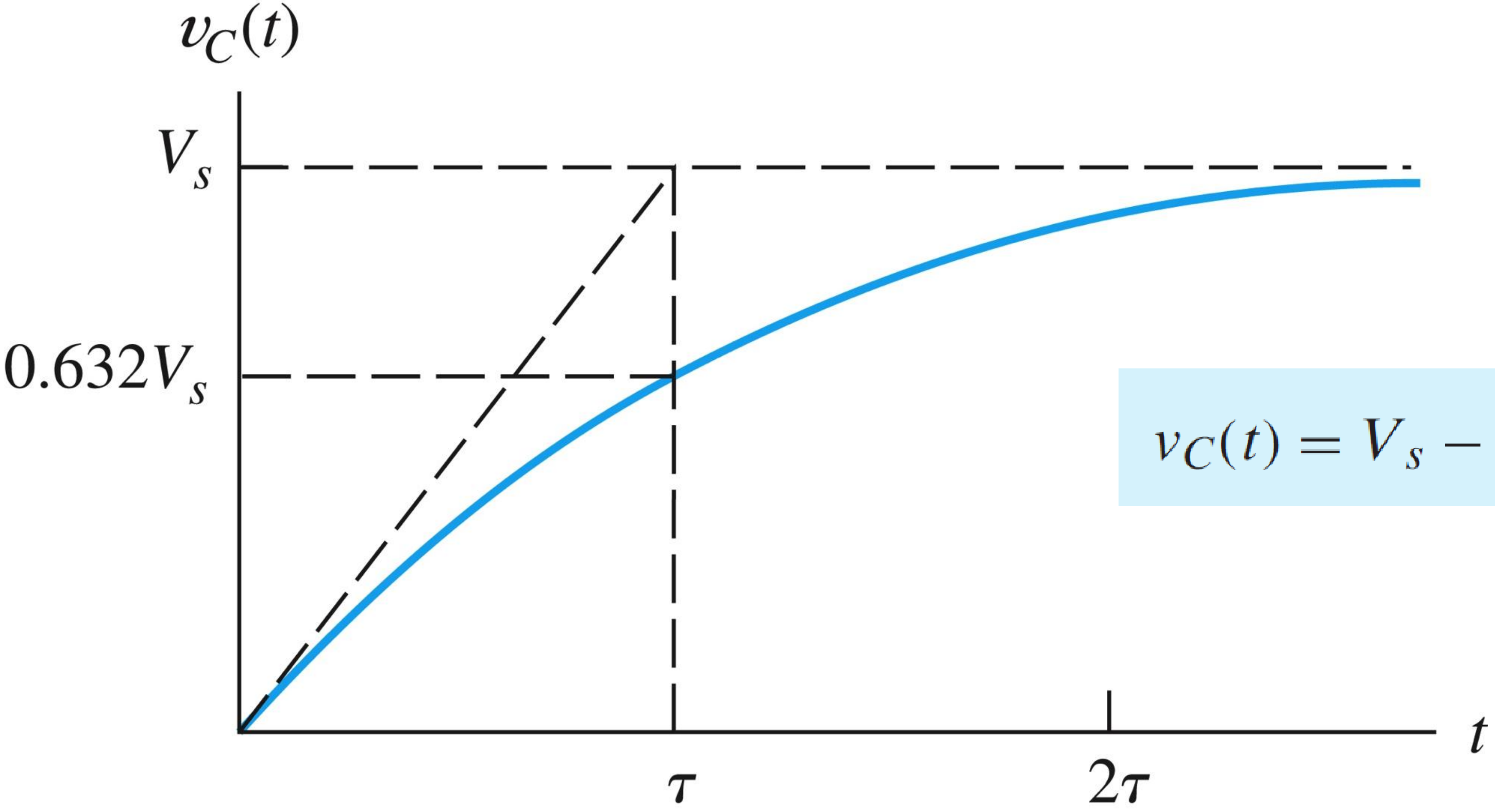
$$C\frac{dv_C(t)}{dt} + \frac{v_C(t) - V_s}{R} = 0 \quad (4.10)$$

$$RC\frac{dv_C(t)}{dt} + v_C(t) = V_s \quad (4.11)$$

Educated guess $v_C = K_1 + K_2 e^{st}$

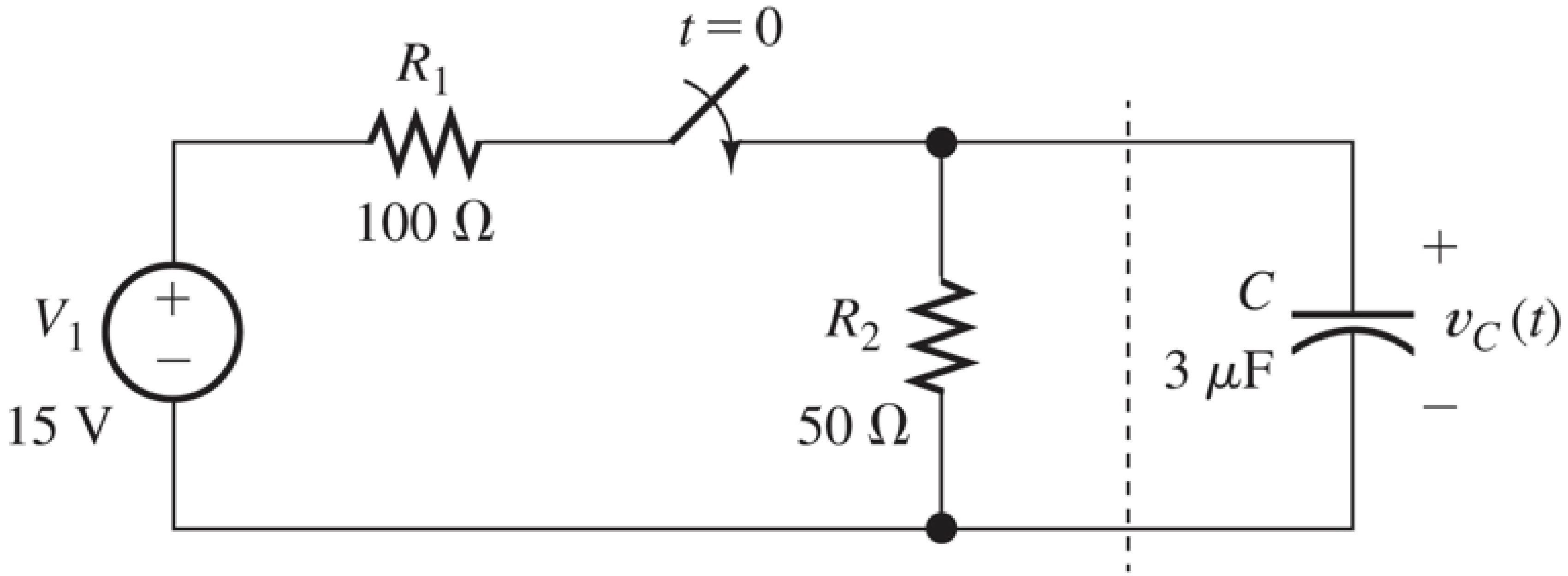
$$v_C(t) = V_s - V_s e^{-t/RC} \quad (4.19)$$

CHARGING A CAPACITOR



$$v_C(t) = V_s - V_s e^{-t/\tau}$$

EXAMPLE 4.2

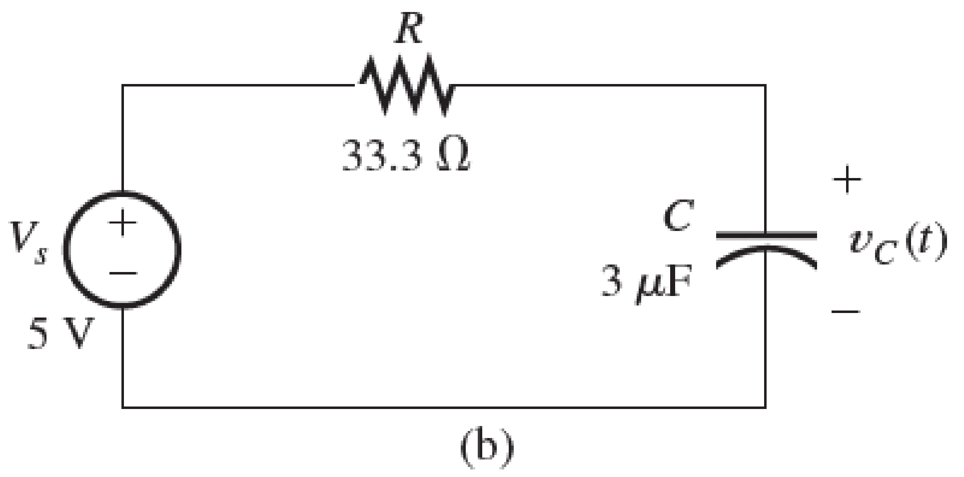


Example 4.2 **First-Order *RC* Circuit**

The switch in the circuit of Figure 4.5(a) has been open for a very long time prior to $t = 0$ and closes at $t = 0$. Find an expression for $v_C(t)$ for $t > 0$.

EXAMPLE 4.2 SOLUTION

- Thévenin equivalent

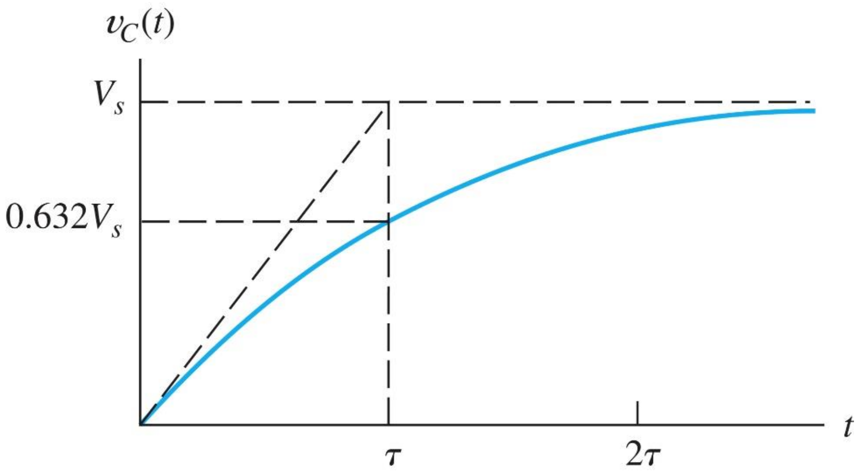


- KCL – or rather, realize that this is a standard 1st order RC circuit in CHARGING mode

$$v_C(t) = V_s - V_s e^{-t/\tau}$$

EXERCISE

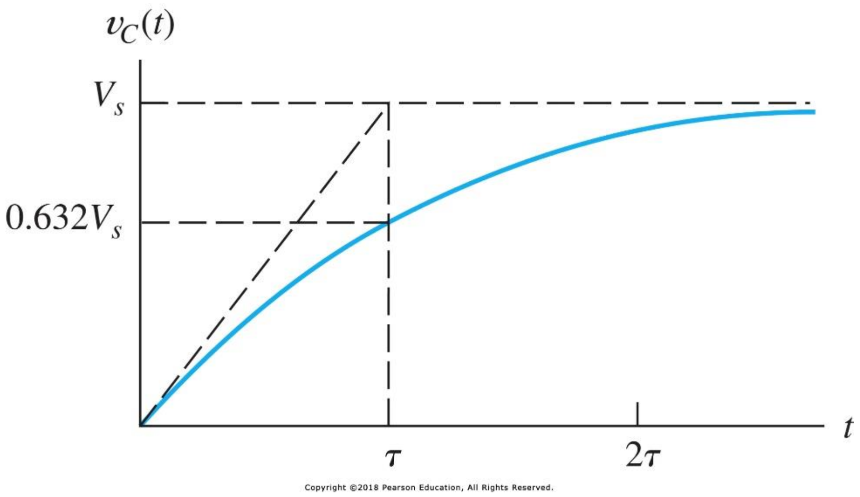
Exercise 4.2 Show that if the initial slope of $v_C(t)$ is extended, it intersects the final value at one time constant, as shown in Figure 4.4. [The expression for $v_C(t)$ is given in Equation 4.20.] □



$$v_C(t) = V_s - V_s e^{-t/\tau}$$

EXERCISE 4.2 – SOLUTION STEP 1

Exercise 4.2 Show that if the initial slope of $v_C(t)$ is extended, it intersects the final value at one time constant, as shown in Figure 4.4. [The expression for $v_C(t)$ is given in Equation 4.20.]



$$v_C(t) = V_s - V_s e^{-t/\tau}$$

$$v_C(t) = V_S\left(1 - e^{-t/\tau}\right)$$

slope: $$\frac{dv_C}{dt} = V_S \frac{d\left(1 - e^{-t/\tau}\right)}{dt} = V_S \frac{1}{\tau} e^{-t/\tau}$$

so, at t=0: slope = $\dfrac{V_S}{\tau}$

PROBLEMS

- P4.3
- P4.8
- P4.13
- P4.14
- P4.17
- P4.18