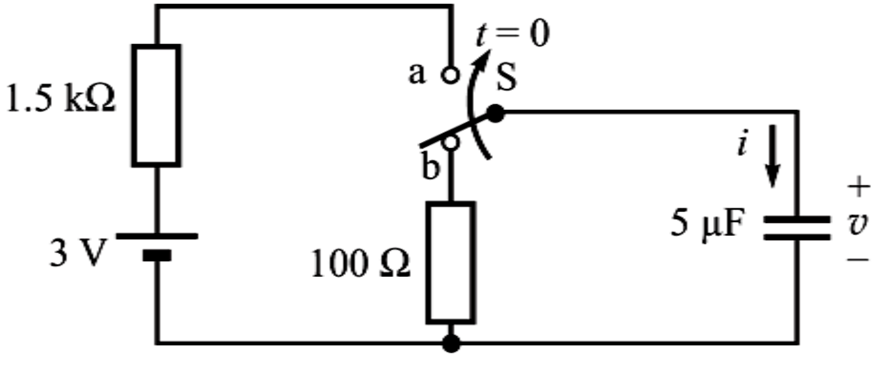
ELECTRICAL SCIENCE-II (15B11EC211)

Example 3



(a) (b)

The single-pole double-throw switch S has been in position b for a long time so that the 5-μF capacitor is fully discharged. Now, at t = 0, the switch is thrown to position a. Determine

- (*a*) $v(0+)$,
- (*b*) $i(0+)$,
- (*c*) time constant τ,
- (*d*) v and i at t = 15 ms.

capacitor mein steady state mein voltage mein convert hoga to i(0) mein time 0 mein kuch change nahi hoga to voltage 0 hoga and infinity time mein voltage milega question 4th ka answer
ab current time 0 par hi milega kyuki t infinty par capacitor open circuit mein convert ho jayega aur fir current 0 ho jayega

Solution :

(*a*) Since the voltage across a capacitor cannot change instantaneously, we have $v(0+) = v(0-) = \mathbf{0\ V}$

(*b*) $$i(0^+) = I_0 = \frac{V_0}{R} = \frac{3\,\text{V}}{1.5\,\text{k}\Omega} = \mathbf{2\ mA}$$

(*c*) $$\tau = RC = (1.5\ \text{k}\Omega)(5\ \mu\text{F}) = \mathbf{7.5\ ms}$$

(*d*) At t = 15 ms :

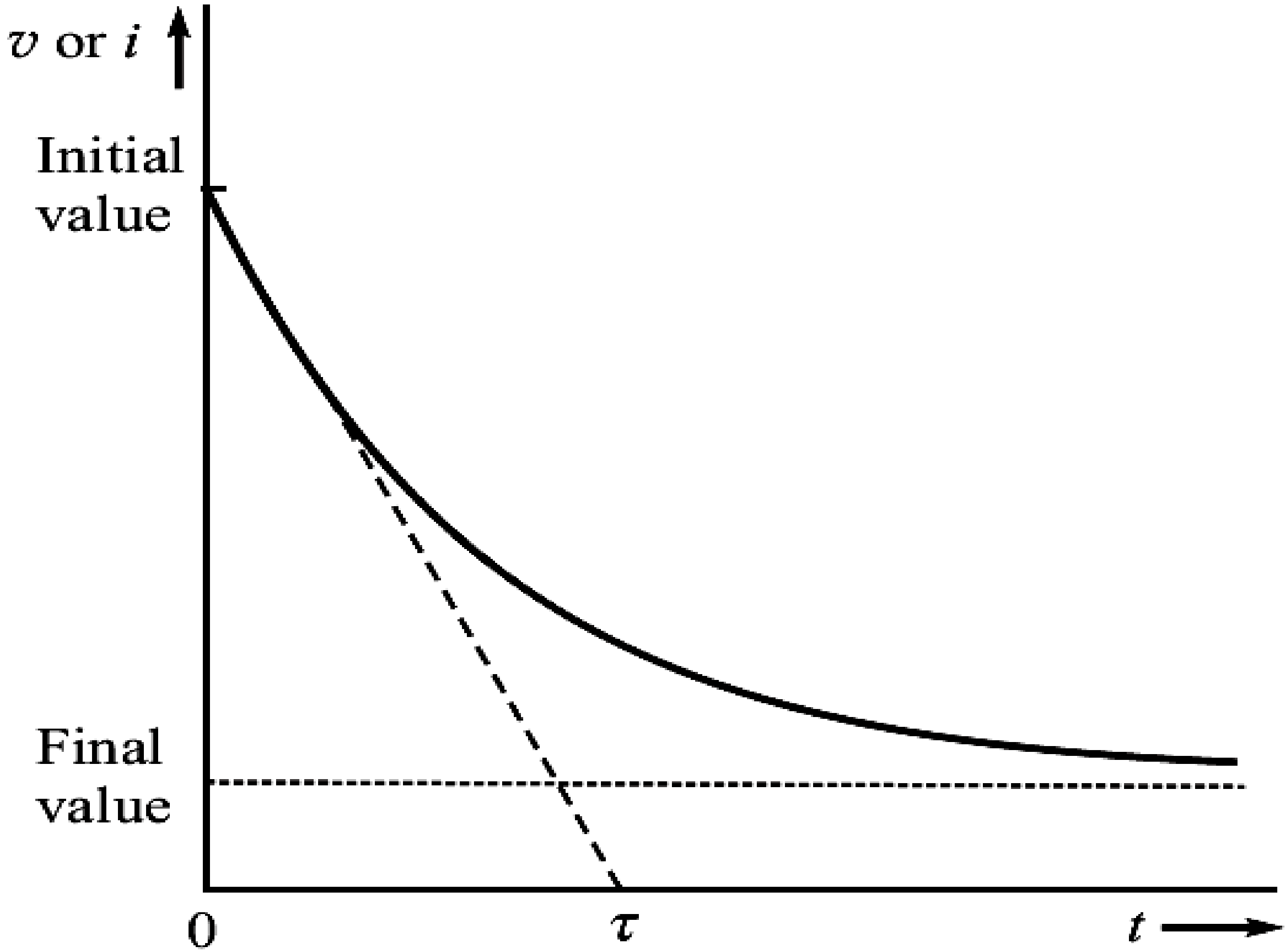
$$v = V_0(1 - e^{-t/\tau}) = 3(1 - e^{-(15\ \text{ms})/(7.5\ \text{ms})}) = \mathbf{2.594\ V}$$

$$i = I_0 e^{-t/\tau} = (2\ \text{mA})\, e^{-(15\,\text{ms})/(7.5\ \text{ms})} = \mathbf{0.27\ mA}$$

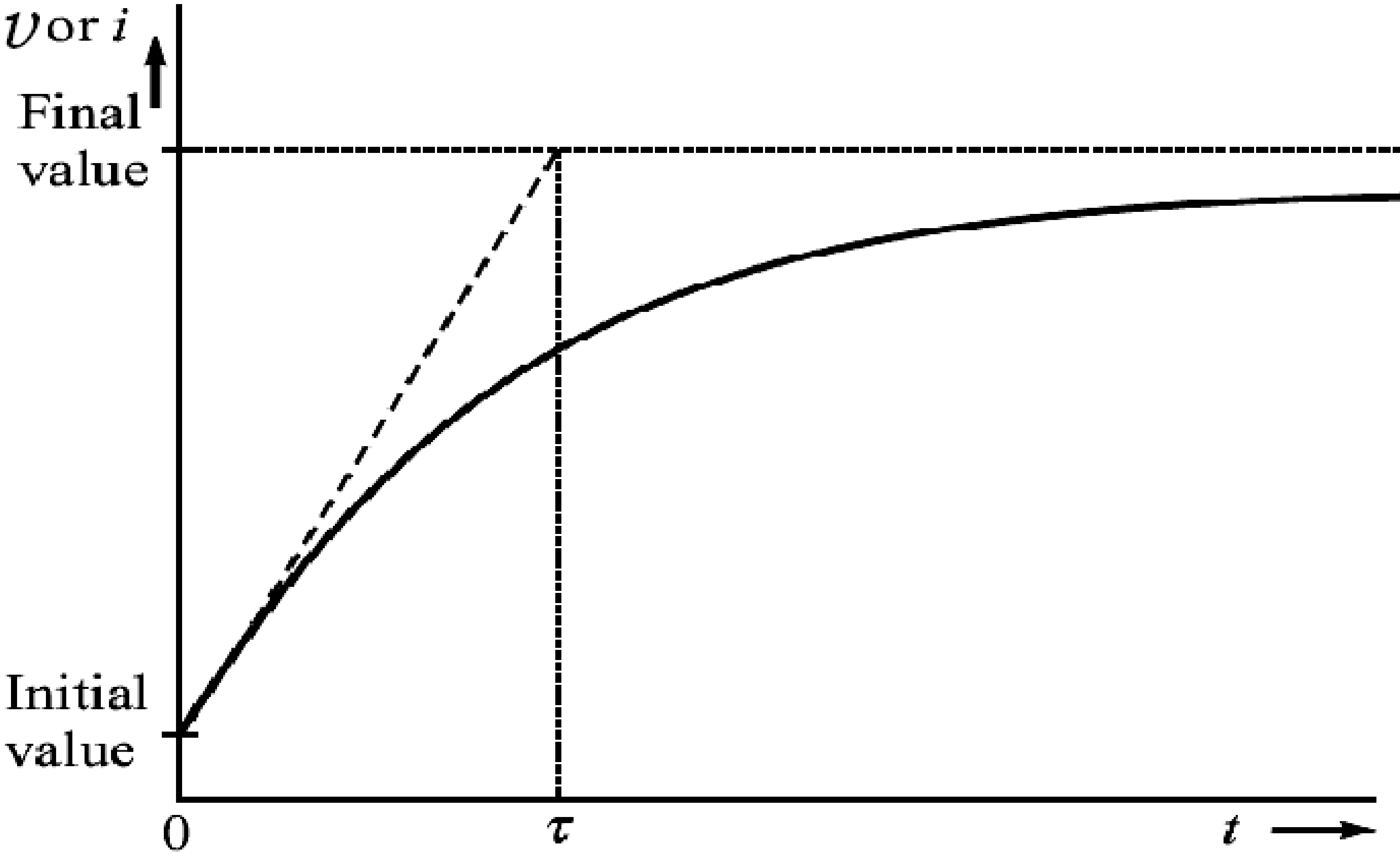
Single-Capacitor *RC* Circuit and Single-Inductor *RL* Circuit

- The ***time constant*** for
  - For *LR* circuit, $\tau = L / R_{\mathrm{Th}}$
  - For *CR* circuit, $\tau = CR_{\mathrm{Th}}$

Here, R_{Th} is Thevenin resistance as "seen" by the capacitor or inductor.



(a) Exponentially decreasing with time.



(b) Exponentially increasing with time.

- The voltages and currents approach their final values asymptotically.
- It means that they never actually reach them.
- However, after *five time-constants* they change by 99.3 % of their total change.

Important Point

(For solving Problems)

If immediately after switching,

$v(0+)$ and $i(0+)$ are *initial values*

and $v(\infty)$ and $i(\infty)$ are *final values*.

Then, the expressions for all the voltages and currents in the circuit for any time t are given as

$$\boxed{\begin{aligned} v(t) &= v(\infty) + [v(0^+) - v(\infty)]e^{-t/\tau} \text{ V} \\ i(t) &= i(\infty) + [i(0^+) - i(\infty)]e^{-t/\tau} \text{ A} \end{aligned}}$$

Comparison between *RC* and *RL* Circuits

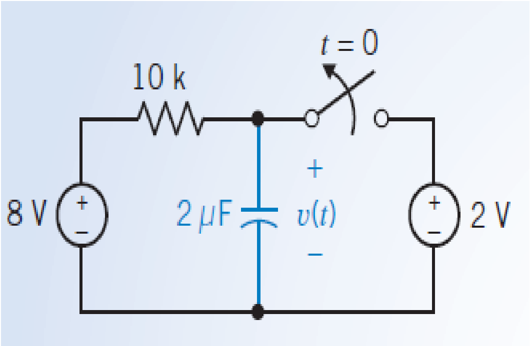
Though both give similar response, but we prefer *RC* over *RL* circuit, because

- Inductors are not as nearly ideal as capacitors.
- Inductors are relatively bulky, heavy and difficult to fabricate, especially using integrated-circuit techniques.
- Inductors are relatively costlier.
- The magnetic field emanating from the inductors can induce unwanted voltages in other components.

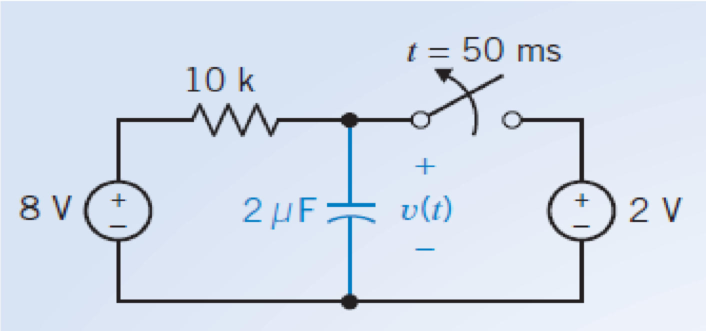
Unsolved Ques. 1: Find the capacitor voltage after the switch opens in the circuit shown in Figure below. What is the value of the capacitor voltage 50 ms after the switch opens?

Answer will remain same i.e. 7.51 volt

(a)



(b)



Complete Solution by the Differential Equation Approach

5 major steps to find the complete solution:

- Determine initial conditions on capacitor voltages and/or inductor currents.
- Find the differential equation for either capacitor voltage or inductor current (mesh/loop/nodal …. analysis).
- Determine the natural solution (complementary solution).
- Determine the forced solution (particular solution).
- Apply initial conditions to the complete solution to determine the unknown coefficients in the natural solution.

Here we will consider three cases for the input to the circuit.

- First case

$$v_s(t) = V_0$$

- Second case

$$v_s(t) = V_0 e^{-t/\tau}$$

- Third case

$$v_s(t) = V_0 \cos(\omega t + \theta)$$

These three cases are special because the forced response will have the same form as the input.