# Basic Electrical Technology

## RL Transient

# Recap

**Network Reduction Tehniques**

- Y-Δ Transformation
- Source Transformation

**Circuit Analysis Techniques**

- Mesh Current **Method**
- Node Voltage Method

**Theorems**

- Thevenin's Theorem
- Superposition Theorem
- Max. Power Transfer Theorem

# Next What?

- So far studied about DC **resistive** network.
- Currents & voltages were **independent** of time.
- In other words, current (response) changed instantly as voltage (cause) changed.

- Will the behaviour be same if inductor or capacitor was present in a circuit?
- Answer is **NO**.
- In inductor, $\mathbf{v_L = L\, di/dt}$

**(Notice that I have not consdered the –ve sign because the direction of the voltage will be taken care of in the circuit diagram I'll draw)**

- **Current** through an inductor **doesn't change instantly** but **voltage can.**

# What is Transient ?

Dictionary

English

transient

**transient**

/ˈtranzɪənt/

*adjective*

lasting only for a short time; impermanent.
"a transient cold spell"

Similar: transitory temporary short-lived short-term ephemeral

*noun*

1. a person who is staying or working in a place for a short time only.
2. a momentary variation in current, voltage, or frequency.

Definitions from Oxford Languages

*Feedback*

Translations and more definitions

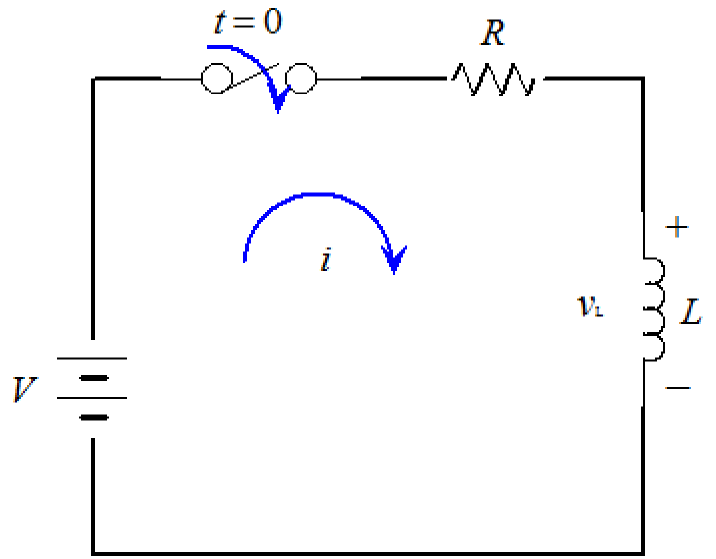
# Growth of Current in an Inductive Circuit

Applying KVL,

$$V - R\,i - L\frac{di}{dt} = 0$$

Initial Conditions,

$$At\ t = 0\ sec, i = 0\ A$$




Final current & voltage equation,

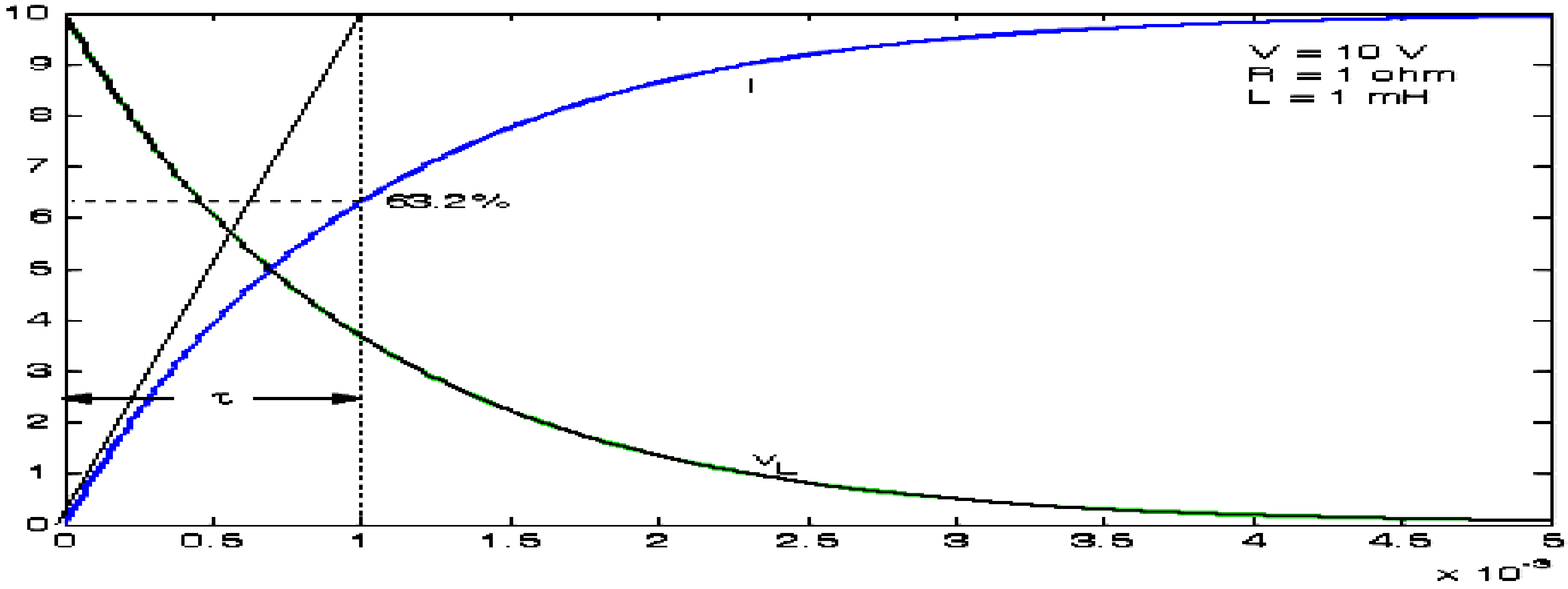
$$i = \frac{V}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

$$v_L = V\,e^{-\left(\frac{R}{L}\right)t}$$

# Growth of current in an inductive circuit

***Time Constant ($\tau$):*** Time taken by the current through the inductor to reach its final steady state value, had the initial rate of rise been maintained constant

$$\tau = \frac{L}{R}$$



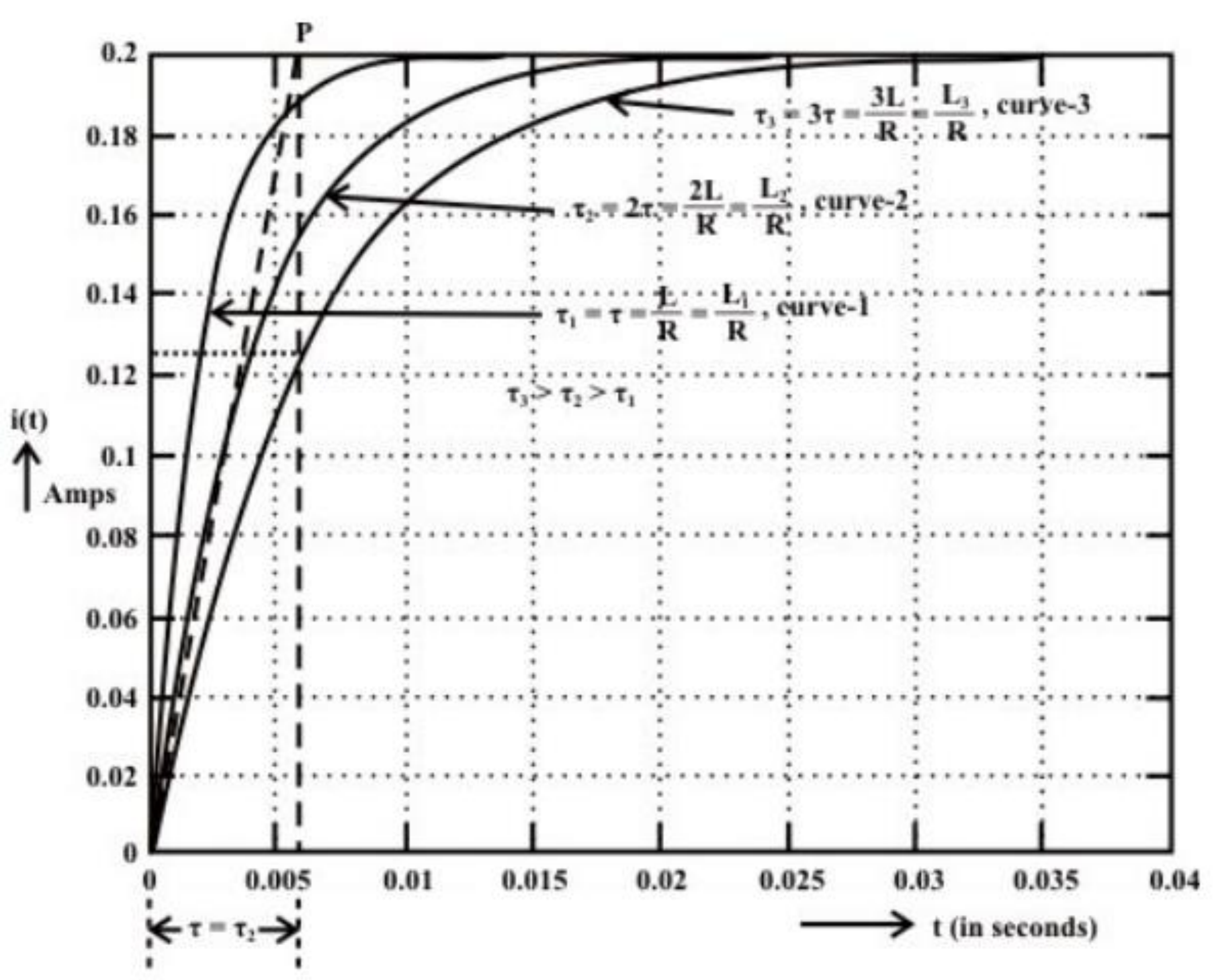
# Growth of current in an inductive circuit

The table shows how the current i(t) builds up in a R-L circuit.

| Actual time (t) in sec | Growth of current in inductor (Eq.10.15) |
|---|---|
| $t=0$ | $i(0)=0$ |
| $t=\tau\left(=\frac{L}{R}\right)$ | $i(\tau)=0.632\times\frac{V_s}{R}$ |
| $t=2\tau$ | $i(2\tau)=0.865\times\frac{V_s}{R}$ |
| $t=3\tau$ | $i(3\tau)=0.950\times\frac{V_s}{R}$ |
| $t=4\tau$ | $i(4\tau)=0.982\times\frac{V_s}{R}$ |
| $t=5\tau$ | $i(5\tau)=0.993\times\frac{V_s}{R}$ |

**Note**: Here $\mathbf{V_s}$ is the source voltage applied (which is same as **V** of previous slide)

# Growth of current in an inductive circuit




**Time Constant** indicates how fast or slow the system response reaches its steady state from the instant of switching the circuit

# Illustration 1

A series R-L circuit having resistance 10 Ω is connected to a 5 V dc voltage source through a switch. At t=0 sec, the switch is turned on.

Find

i. The maximum current that will flow in the circuit.

ii. The inductance if 0.2 A current flows in the circuit at 1 ms after the voltage source is switched on.

Assume that initially no energy is stored in the inductor.

**Ans:**

**i. $I_0 = 0.5$ A**

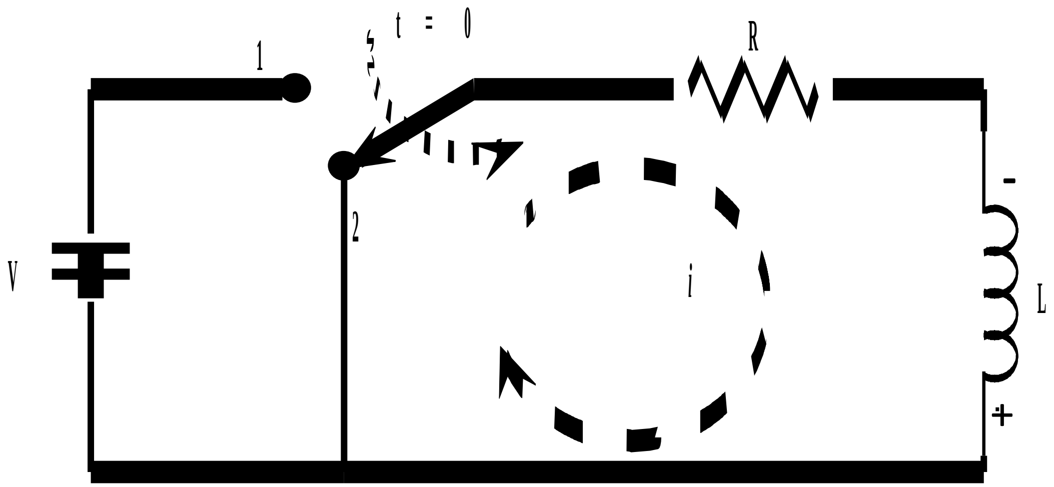
**ii. L = 20 mH (approx.)**

# Decay of current in an Inductive Circuit

- Initial current is through inductor is

$$I_0 = V/R$$

- At $t = 0$, switch is moved from position ***a*** to ***b***




Applying KVL,

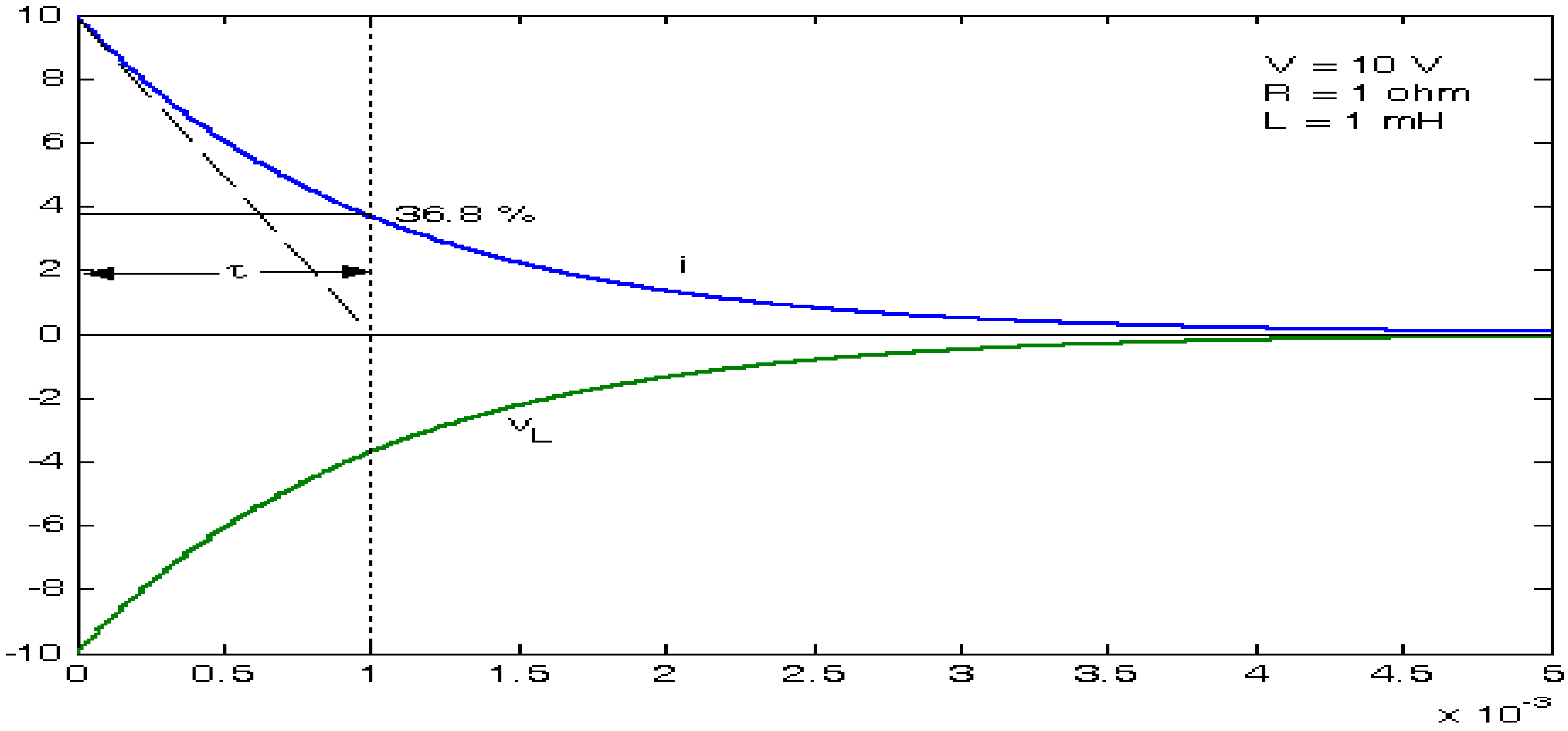
$$L\frac{di}{dt} + R\,i = 0$$

Using initial conditions and then solving

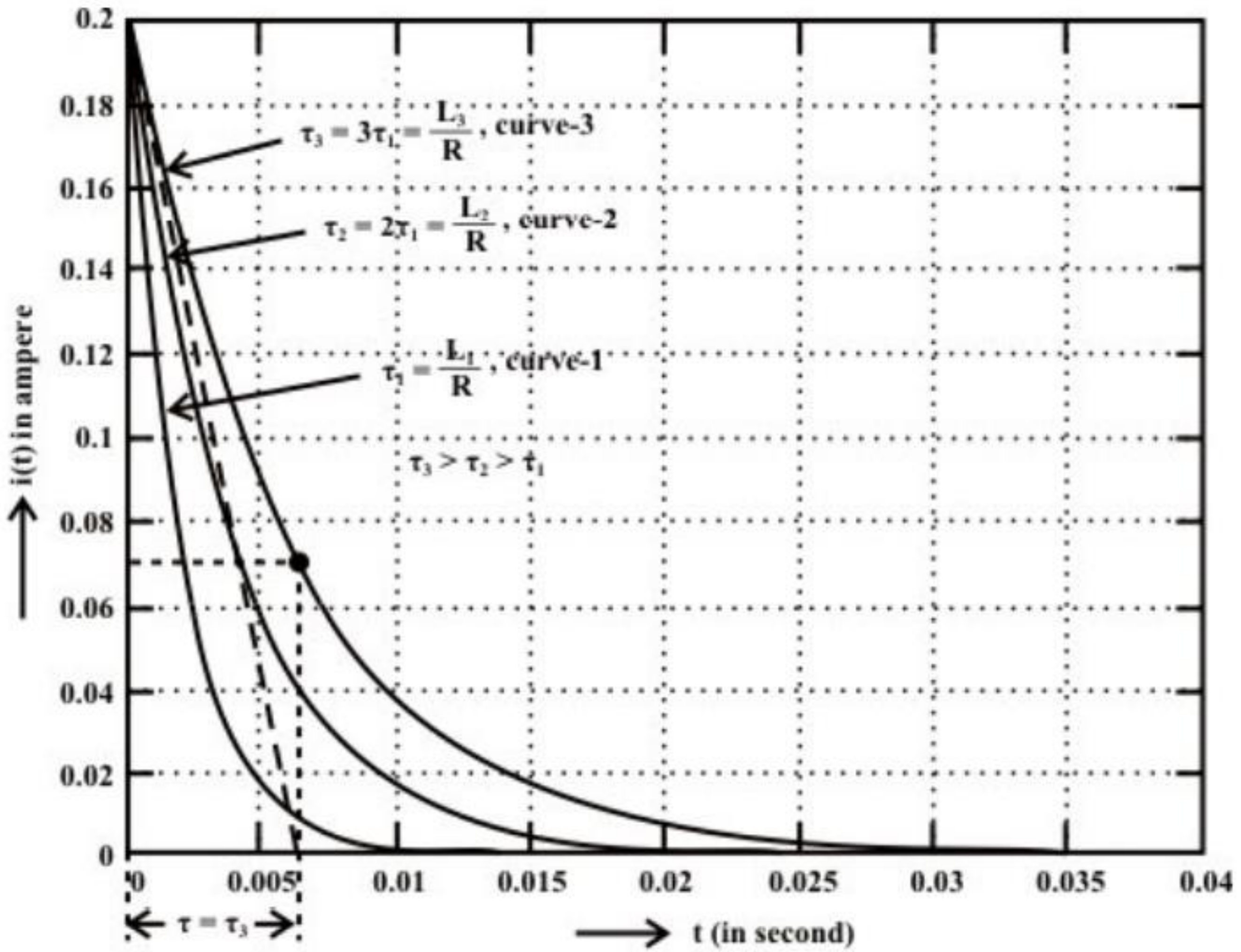
$$i = I_0 e^{\left(\frac{-Rt}{L}\right)}$$

$$v_L = -V\,e^{-\left(\frac{Rt}{L}\right)}$$

# Decay of current in an Inductive Circuit



# Decay of current in an Inductive Circuit




**Time Constant** indicates how first or slow the system response decays after the source is removed.

# Some Remarks

- Current flowing through an inductor **cannot** change instantaneously (i.e. $\boldsymbol{i}(\mathbf{0}^{-}) = \boldsymbol{i}(\mathbf{0}^{+})$).

- Voltage across an inductor **can** change abruptly.

- Inductor acts as **short-circuit** when current flowing through it does not change.

# Illustration 2

A coil of resistance 5 Ω and inductance of 20 mH is connected to a battery of voltage 12 V for a long time. At t = 0, the coil is short circuited. Find the time taken for the current to reach the value 1.2 A.

**Ans: 2.77 ms**

# Illustration 3

In the circuit shown below, both the switches, $S_1$ & $S_2$ , are open initially. At t = 0 sec, $S_1$ is closed (& $S_2$ remains open). At t = 4 ms $S_2$ is closed. Sketch the inductor current $\boldsymbol{i(t)}$ for $0 \le t \le 25$ ms.