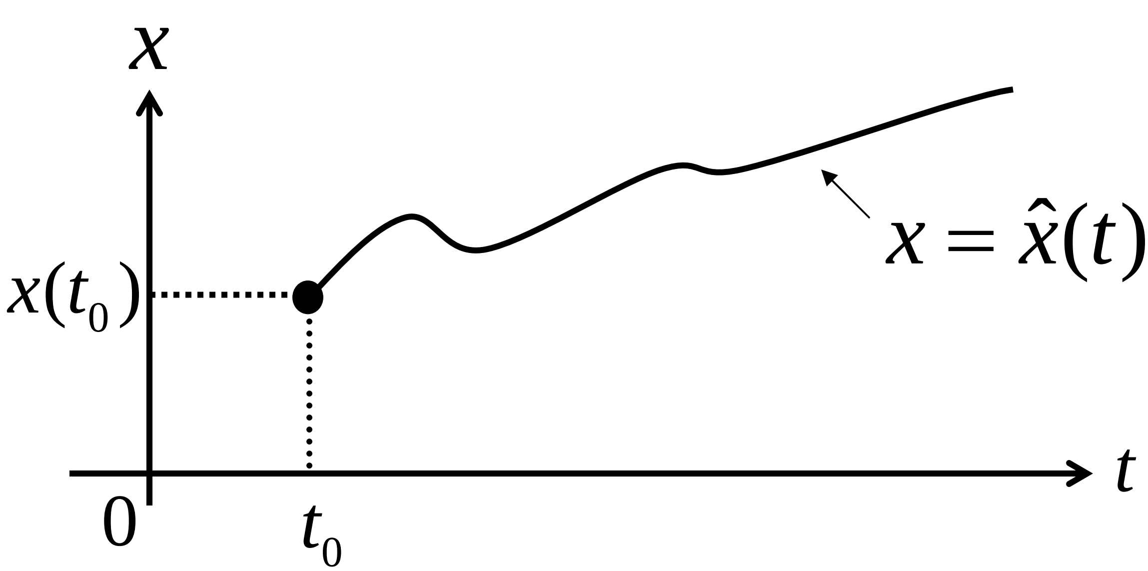
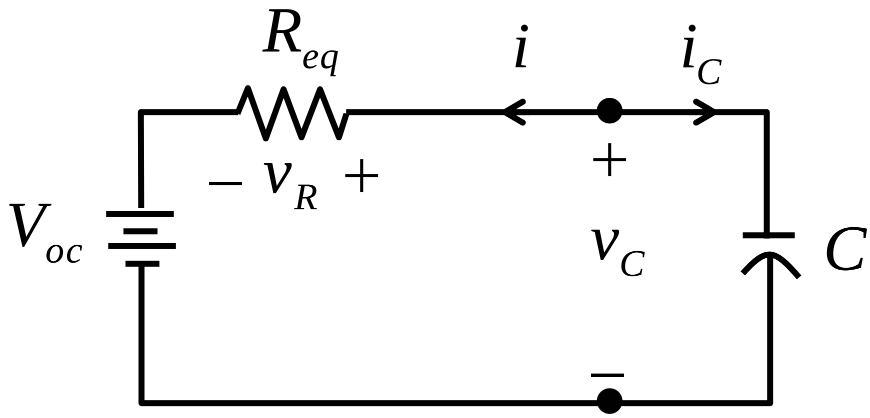
The solution of **differential equation**

$$\frac{dx}{dt} = -\frac{x}{\tau} + \frac{x(t_\infty)}{\tau}$$

with a given **initial condition** $x(t_0)$ at $t = t_0$ is a time function $\hat{x}(t)$ (waveform) which satisfies both the differential equation and the initial condition.





$$\text{KCL} \Rightarrow \; i = -i_C$$

$$\text{KVL} \Rightarrow \; v_R = v_C - V_{oc}$$

$$\text{Ohms law} \Rightarrow \; i = \frac{v_R}{R_{eq}} = \frac{v_C - V_{oc}}{R_{eq}}$$

$$\text{capacitor law} \Rightarrow \; i_c = C\frac{dv_C}{dt}$$

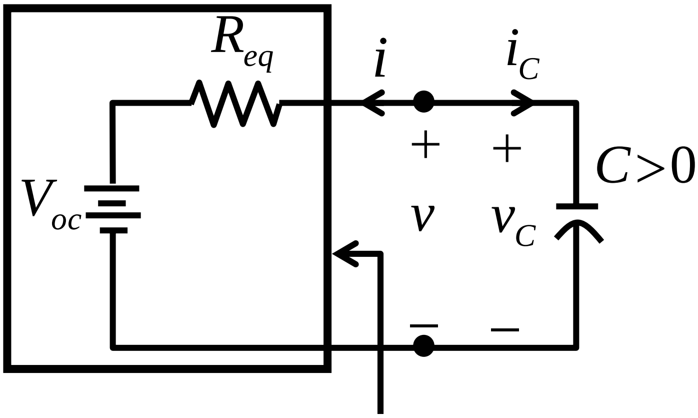
$$= -i$$

$$= -\frac{\left(v_C - V_{oc}\right)}{R_{eq}}$$

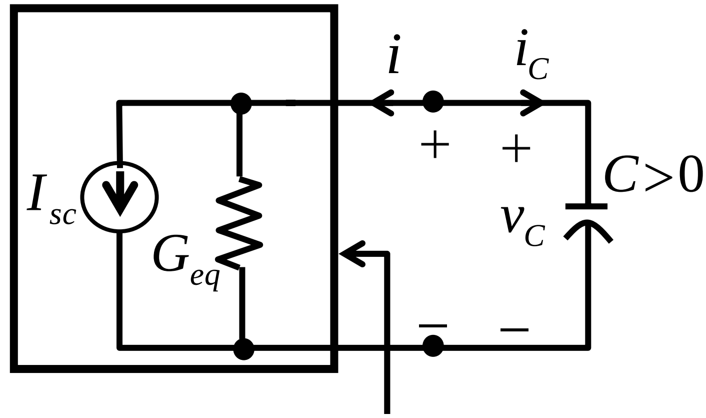
$$\boxed{\frac{dv_C}{dt} = -\frac{v_C}{R_{eq}C} + \frac{V_{oc}}{R_{eq}C}}$$

$$\text{define } x \triangleq v_C \;, \quad x(t_\infty) \triangleq V_{oc}, \quad \tau \triangleq R_{eq}C$$

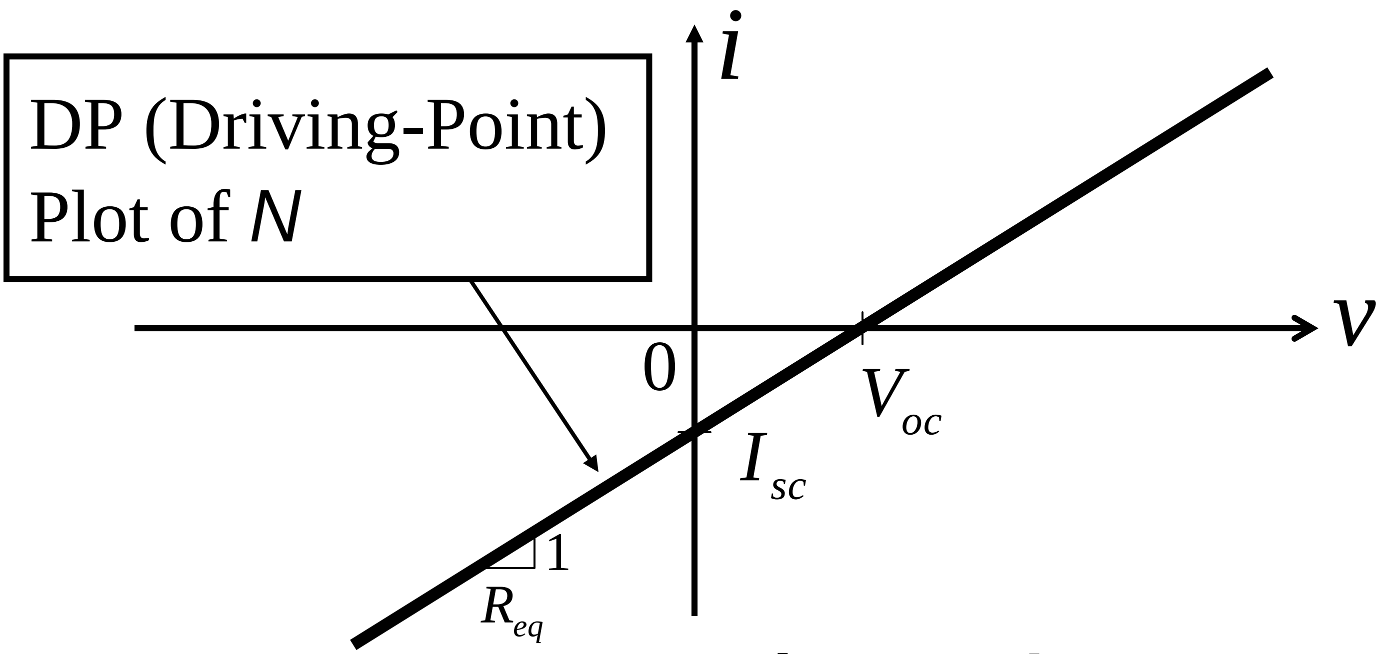
$$\boxed{\frac{dx}{dt} = -\frac{x}{\tau} + \frac{x(t_\infty)}{\tau}}$$



Thevenin Equivalent circuit *N*



Norton Equivalent circuit *N*



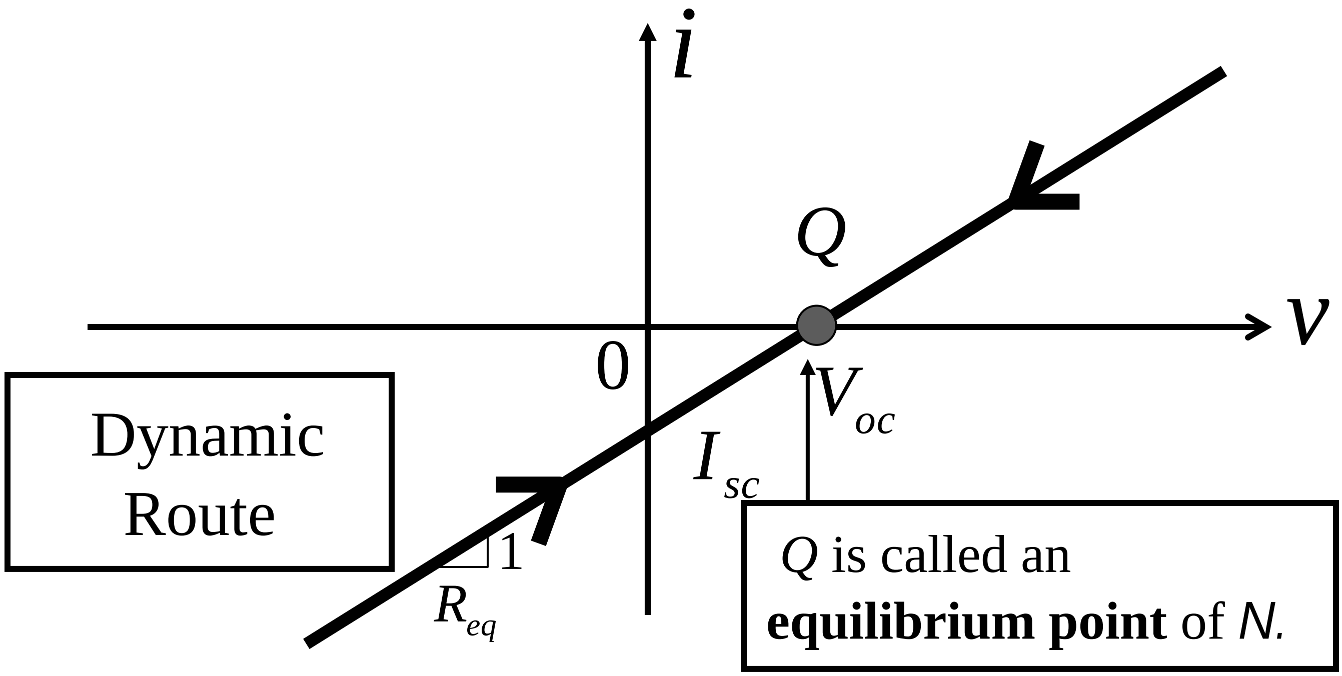
$$i(t) = -i_C(t) = -C\frac{dv_C}{dt} = -C\frac{dv}{dt}$$

$$C > 0 \Rightarrow$$

$$\left.\frac{dv(t)}{dt}\right|_{t=t_k} > 0 \quad \text{iff} \quad \left.i(t)\right|_{t=t_k} < 0$$

$$\left.\frac{dv(t)}{dt}\right|_{t=t_k} < 0 \quad \text{iff} \quad \left.i(t)\right|_{t=t_k} > 0$$

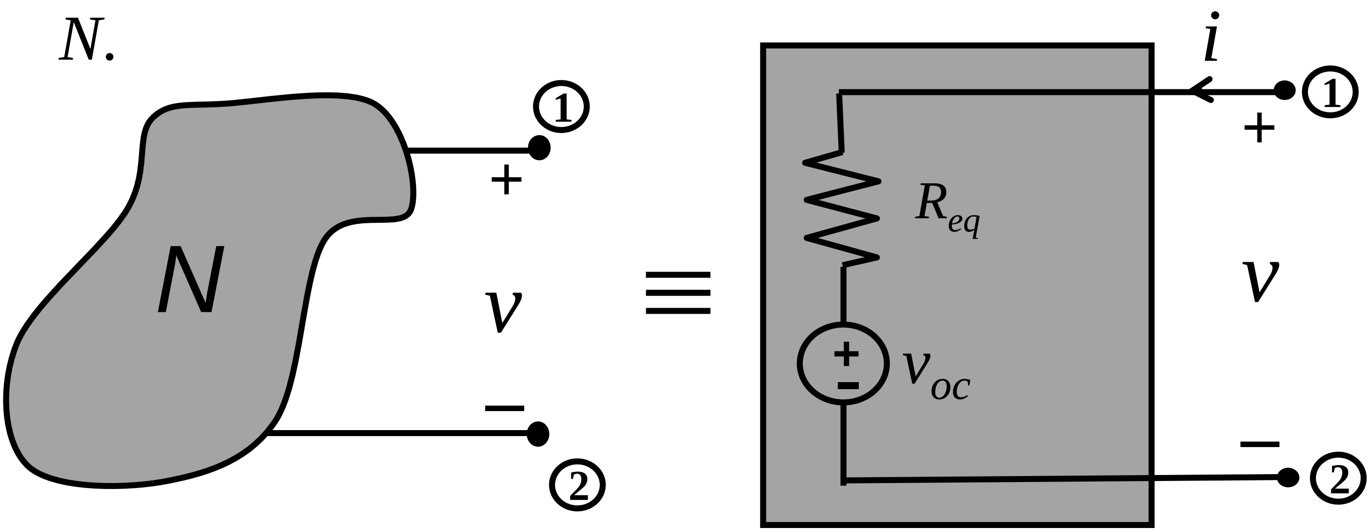
$$\left.\frac{dv(t)}{dt}\right|_{t=t_k} = 0 \quad \text{iff} \quad \left.i(t)\right|_{t=t_k} = 0$$



i
v
Q
0
V_{oc}
I_{sc}
1
R_{eq}
Dynamic Route
Q is called an **equilibrium point** of N.

Thevenin's Theorem

We can substitute the 2-terminal box N with an **equivalent** one-port called the **Thevenin Equivalent Circuit** made of a **linear resistance** R_{eq}, called the Thevenin **equivalent resistance**, **in series** with an independent voltage source v_{oc}, called the Thevenin **open-circuit voltage**, without affecting the solutions inside ***any*** external circuit N_{ext} connected across N.



Linear Resistive One-port

Thevenin Equivalent One-port

Norton's Theorem

We can substitute the 2-terminal box N with an **equivalent** one-port called the **Norton Equivalent Circuit** made of a **linear conductance** G_{eq}, called the Norton **equivalent conductance**, **in parallel** with an independent current source i_{sc}, called the Norton **short-circuit current**, without affecting the solutions inside ***any*** external circuit Next connected across N.