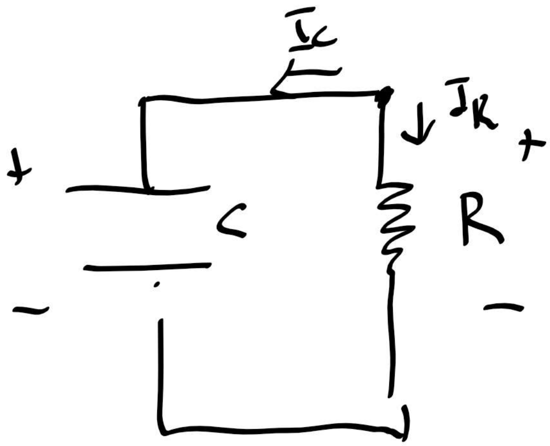
RC:

$$\dot{V}_C = \frac{dV_C}{dt}$$



$$I_C + I_R = 0$$

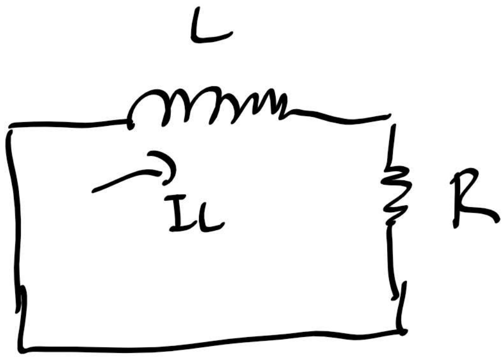
$$C\dot{V}_C + \frac{V_R}{R} = 0$$

$$C\dot{V}_C + \frac{V_C}{R} = 0$$

$$\boxed{\dot{V}_C = \boxed{-\frac{1}{RC}} V_C}$$

$$V_C(t) = V_0 e^{-t\boxed{/RC}}$$

RL:



$$\boxed{\dot{I}_L = \boxed{-\frac{R}{L}} I_L}$$

$$I_L(t) = I_0 e^{\boxed{-\frac{R}{L}} t}$$

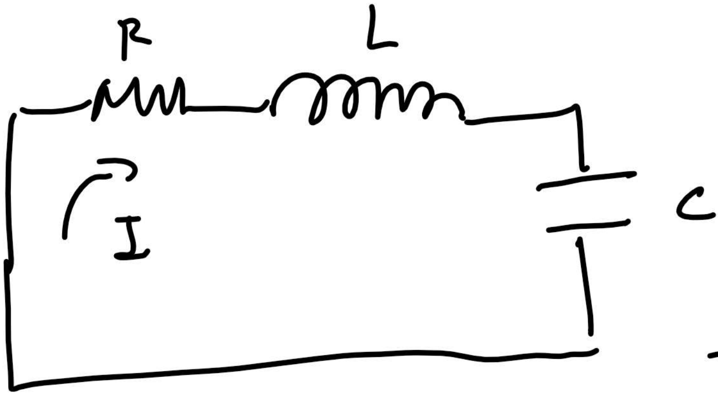
$$\dot{V}_C = -\frac{1}{RC} V_C$$

$$V_C(t) = V_0 e^{-t/RC}$$

$$\dot{V}_C(t) = \frac{d\,V_C(t)}{dt} = -\frac{1}{RC} \underbrace{V_0 e^{-t/RC}}$$

$$\dot{V}_C(t) = -\frac{1}{RC} V(t)$$

RLC:



$$V_R + V_L + V_C = 0$$

$$RI + L\dot{I} + V_C = 0$$

$$\rightarrow I = C\dot{V}_C = C\frac{dV_C}{dt}$$

$$RC\frac{dV_C}{dt} + LC\frac{d^2V_C}{dt} + V_C = 0$$

$$\boxed{\frac{d^2V_C}{dt} = -\frac{1}{LC}V_C - \frac{R}{L}\frac{dV_C}{dt}}$$

$$X = \begin{bmatrix} V_C \\ \frac{dV_C}{dt} \end{bmatrix}$$

$$\frac{dX}{dt} = \begin{bmatrix} \frac{dV_C}{dt} \\ \frac{d^2V_C}{dt} \end{bmatrix} = \begin{bmatrix} dV_C/dt \\ -\frac{1}{LC}V_C - \frac{R}{L}\frac{dV_C}{dt} \end{bmatrix}$$

$$X = \begin{bmatrix} V_C \\ \frac{dV_C}{dt} \end{bmatrix}$$

$$\frac{dX}{dt} = \begin{bmatrix} \frac{dV_C}{dt} \\ \frac{d^2V_C}{dt} \end{bmatrix} = \begin{bmatrix} dV_C/dt \\ -\frac{1}{LC}V_C - \frac{R}{L}\frac{dV_C}{dt} \end{bmatrix}$$

$$\frac{dX}{dt} = \underbrace{\begin{bmatrix} 0 & 1 \\ -\frac{1}{LC} & -\frac{R}{L} \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} V_C \\ \frac{dV_C}{dt} \end{bmatrix}}_{X}$$

$$\frac{dX}{dt} = A X$$

$$X(t) = e^{At} x_0$$

$$A = V \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} V^{-1} \qquad e^{At} = V \begin{bmatrix} e^{\lambda_1 t} & 0 \\ 0 & e^{\lambda_2 t} \end{bmatrix} V^{-1}$$

$$A = \begin{bmatrix} 0 & 1 \\ -\frac{1}{LC} & -\frac{R}{L} \end{bmatrix}$$

$$\det\left(A - \lambda I \right) = \det \begin{bmatrix} -\lambda & 1 \\ -\frac{1}{LC} & -\frac{R}{L} - \lambda \end{bmatrix}$$

$$= -\lambda \left(-\frac{R}{L} - \lambda \right) + \frac{1}{LC}$$

$$= \lambda^2 + \frac{R}{L}\lambda + \frac{1}{LC} = 0$$