$$i = C\frac{dv}{dt} \quad ; \quad \frac{dv}{dt} = \frac{i}{C}$$

Key equation for capacitors

$$v_C = \int dv = \int \frac{i}{C}\, dt$$

$i = I\sin(wt)$

$$= \int \frac{I}{C} \sin wt\, dt$$

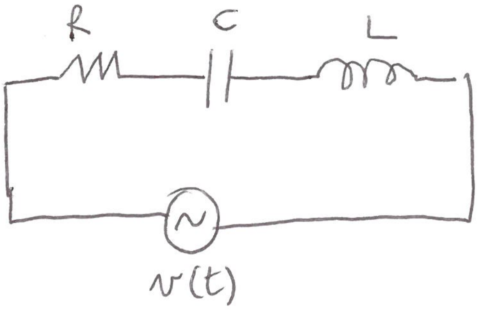
$$= -\frac{I}{wC}\cos(wt) = \frac{I}{wC}\sin\left(wt - \frac{\pi}{2}\right) \quad ; \quad \boxed{X_C = \frac{1}{wC}}$$

$$-\cos(wt) = \sin\left(wt - \frac{\pi}{2}\right)$$

$$v = \frac{di}{dt} L \quad ; \quad di = VL\,dt$$

Key equation inductors

$$= I w \cos(wt)\cdot L = I w L \sin\left(wt + \frac{\pi}{2}\right) \qquad \boxed{X_L = wL}$$



$$v(t) = V_R + V_C + V_L$$

conservation of energy

$\downarrow$

$$v = Ri + \frac{1}{C}\int i\,dt + L\frac{di}{dt}$$

$$\frac{dv}{dt} = \underbrace{R\frac{di}{dt}}_{\text{viscous term}} + \underbrace{\frac{i}{C}}_{\text{drive}} + \underbrace{L\frac{d^2 i}{dt^2}}_{\text{elastic force}}$$

$$a(t) = A\cos(\omega t)$$
$\downarrow$
$$\tilde{a}(t) = A e^{j\omega t}$$

e.m. wave, Spin dynamics

$j \rightarrow$ complex unit

$$a(t) = Re\left(\tilde{a}(t)\right)$$

$$e^{j\omega t} = \cos\omega t + j\sin\omega t$$

$$v = Ve^{j\omega t}$$
$$i = Ie^{j\omega t}$$

$$Vj\omega \cancel{e^{j\omega t}} = -\omega^2 L I \cancel{e^{j\omega t}} + j\omega R I \cancel{e^{j\omega t}} + \frac{1}{C} I \cancel{e^{j\omega t}}$$

$$V = I\left(j\omega L + R + \frac{1}{j\omega C}\right) = I Z$$

$Z \rightarrow$ complex impedance $\in \mathbb{C}$

$$Z = R + j\omega L + \frac{1}{j\omega C} =$$
$$= \underbrace{R}_{\equiv Z_R} + \underbrace{jX_L}_{\equiv Z_L} + \underbrace{\frac{1}{j}X_C}_{\equiv Z_C} = R + j(X_L - X_C)$$

v, i

Ohm's law using complex impedance

$$\boxed{V = Z I = |Z|\, I\, e^{j\varphi} \qquad \tan\varphi = \frac{Im(Z)}{Re(Z)}}$$