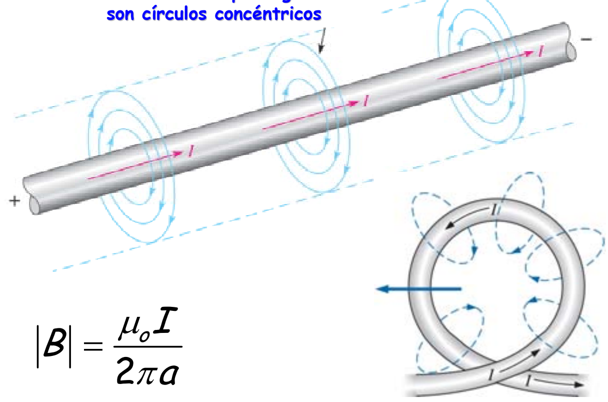
# Bobinas (Inductores)

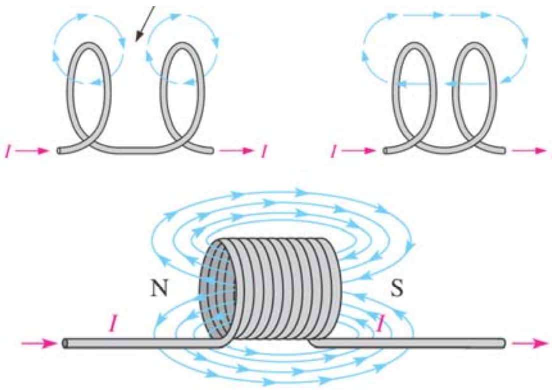
Dpto. de Física. Facultad de Ciencias Físico-Mat. y Nat. (UNSL)

Las líneas de campo magnético son círculos concéntricos



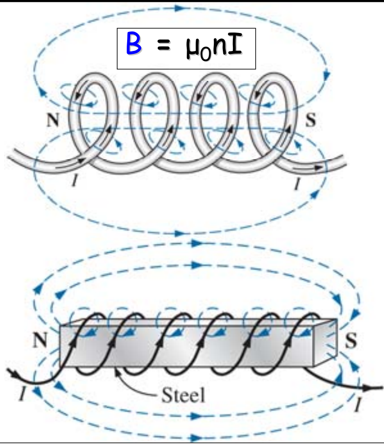

$$|B| = \frac{\mu_o I}{2\pi a}$$

## Inductor

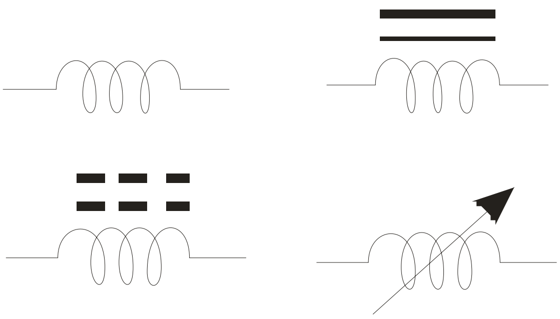



## Inductor

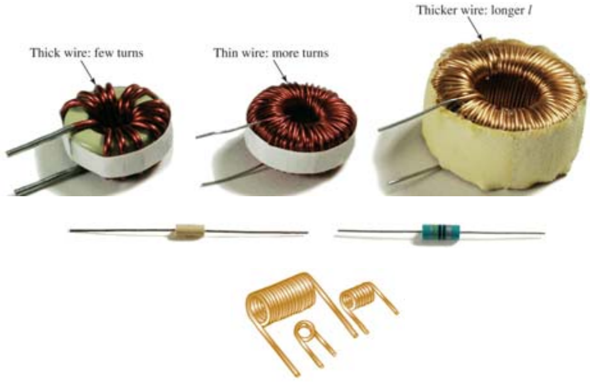
$$B = \mu_0 n I$$

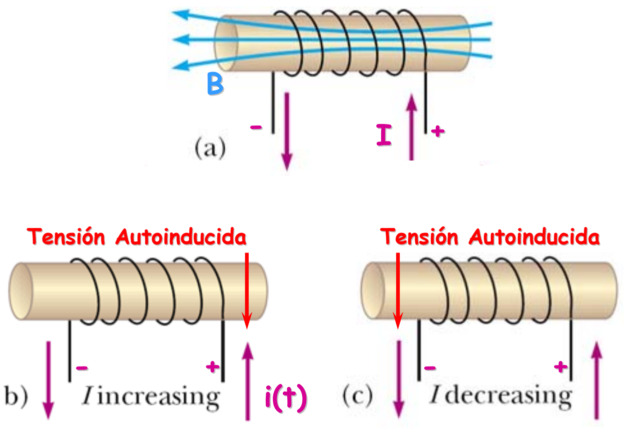



## Símbolo eléctrico de un Inductor



## Inductores Comerciales:






Ley de Faraday:

$$\boxed{\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}}$$

$\Phi_B$ ~ i(t)

$\Phi_B$ =Ki(t)

$$\boxed{\varepsilon = -(KN)\frac{di(t)}{dt}}$$

L=(KN)

Tensión Autoinducida $\boxed{\varepsilon = -L\frac{di(t)}{dt}}$

*L* es la *AUTOINDUCTANCIA* del Inductor ó simplemente *INDUCTANCIA*

*La INDUCTANCIA* es la propiedad que tiene todo conductor, de oponerse a que la corriente eléctrica cambie, generando una tensión inducida que se opone al cambio que la produce. (Ley de Lenz)

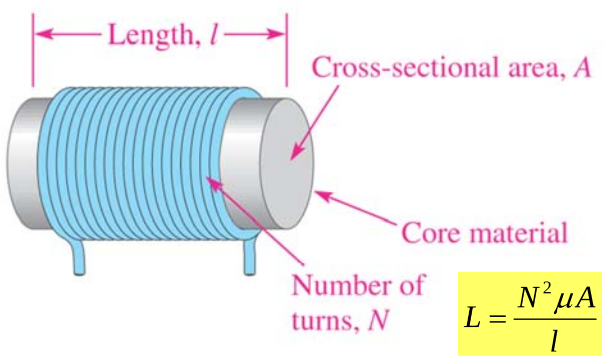
L se mide en Henry (H)

$$\boxed{\varepsilon = -L\frac{di(t)}{dt}}$$

H = s.Volts/A

**Joseph Henry**: (1797-1878) Físico y Matemático estadunidense. Fue el primer director del Instituto Smithsonian.

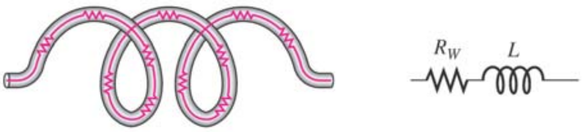
Características de los inductores:




$$L = \frac{N^2 \mu A}{l}$$

La Inductancia sólo depende de factores geométricos y del material.

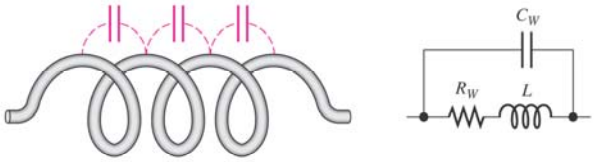
## Características de los inductores:




(a) The wire has resistance distributed along its length.

(b) Equivalent circuit

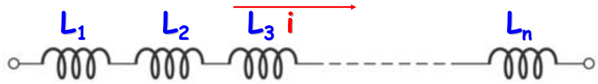
## Características de los inductores:




(a) Stray capacitance between each loop appears as a total parallel capacitance ($C_W$).

(b) Equivalent circuit

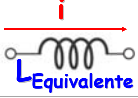
## Combinación de Inductores en Serie:




$v_1 = L_1 \frac{di}{dt}$ $\quad v_2 = L_2 \frac{di}{dt}$ $\quad v_3 = L_3 \frac{di}{dt}$ $\quad v_n = L_n \frac{di}{dt}$

$$v_{Total} = v_1 + v_2 + v_3 + \ldots v_n = (L_1 + L_2 + L_3 + \ldots L_n)\frac{di}{dt}$$

$$\boxed{L_{equivalente} = L_1 + L_2 + L_3 + \ldots L_n}$$

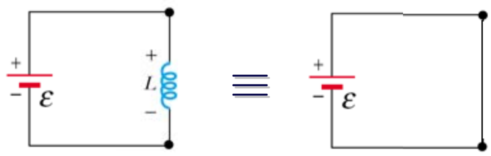



## Comportamiento de un Inductor en Continua

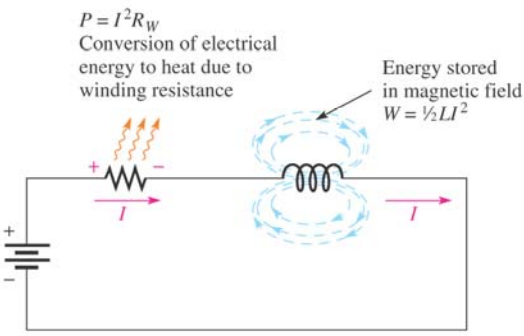
$$v = L\frac{di(t)}{dt}$$

*** La i no puede cambiar en forma instantánea en un inductor**

**En Continua un Inductor se comporta como un corto circuito**




## Energía Almacenada en el campo magnético del Inductor:




## Energía Almacenada en el campo magnético del Inductor:

p(t)=v(t)i(t) $\qquad$ p(t)=dw(t)/d(t)

v(t)=Ldi(t)/dt

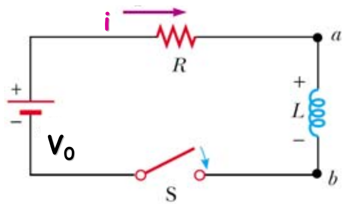
dw(t)/d(t)=Li(t)di(t)/dt

$$\boxed{w(t)=\tfrac{1}{2}Li^2(t)}$$

# Estado Estacionario

# Estado Transitorio

## Circuitos RL:




$V_0 - V_L(t) - V_R(t) = 0$

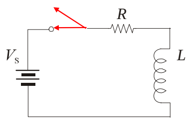
$V_L(t) = L\,di(t)/dt$

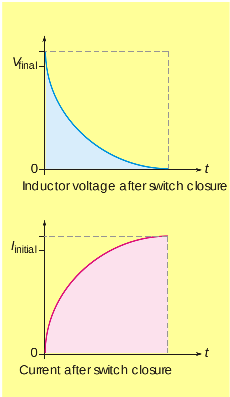
$V_R(t) = i(t)R$

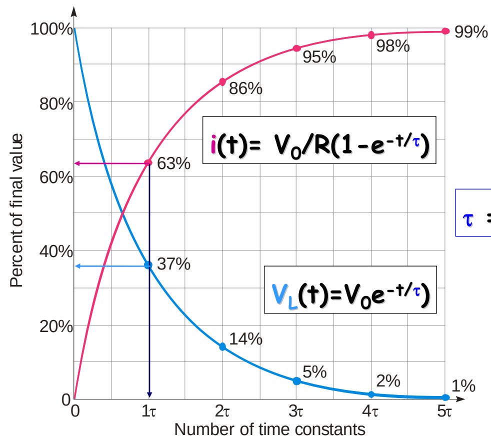
$V_0 - L\,di(t)/dt - i(t)R = 0$

$i(t) = V_0/R(1 - e^{-t/\tau})$ $\quad \tau = L/R \quad$ $V_L(t) = V_0 e^{-t/\tau}$

Cuando un inductor es conectado en serie con una resistencia y una fuente de tensión continua:



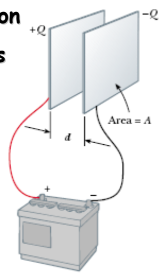




$\tau = L/R$

# Capacitores (Condensadores)



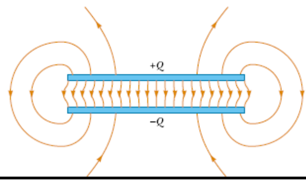
**Capacitor:** es un par de conductores con cargas de igual magnitud pero signos opuestas

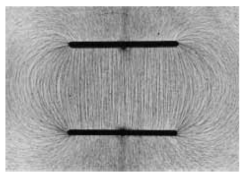



**Definición de Capacidad: $C = Q/\Delta V$**

*La capacitancia de un capacitor es la cantidad de carga que puede almacenar por unidad de Tensión.*

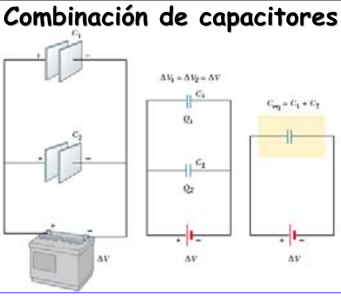
Unidad [Faraday]=[Cuolombs]/[Volts]



## Combinación de capacitores:

$\boxed{C = Q/\Delta V}$

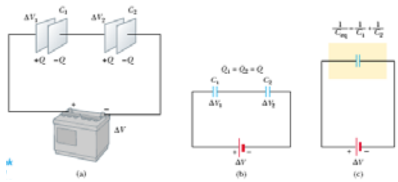


**Paralelo**

$Q_{total} = Q_1 + Q_2$

$C_{Equiv}\Delta V = C_1\Delta V + C_2\Delta V$

$\boxed{C_{Equivalente} = C_1 + C_2}$



**Serie**

$\Delta V = \Delta V_1 + \Delta V_2$

$Q/C_{Equiv} = Q/C_1 + Q/C_2$

$\boxed{1/C_{Equiv} = 1/C_1 + 1/C_2}$

## Energía Almacenada en un capacitor cargado

$\boxed{C = Q/\Delta V}$

$dW = \Delta V dq = (q/C)dq$

$W = Q^2/2C$

$\boxed{U = Q^2/2C = Q\Delta V/2 = C\Delta V^2/2}$

360 Joules en 2 ms. 3000 Veces la potencia de una Lamparita de 60 W!

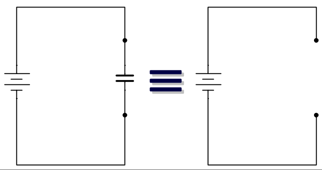
## Comportamiento de los Capacitores en Continua.

$\boxed{Q = C\Delta V}$

$\boxed{\Delta Q/\Delta t = C\Delta V/\Delta t}$

$\boxed{I = CdV/dt}$

En Continua, un capacitor se comporta como un circuito abierto



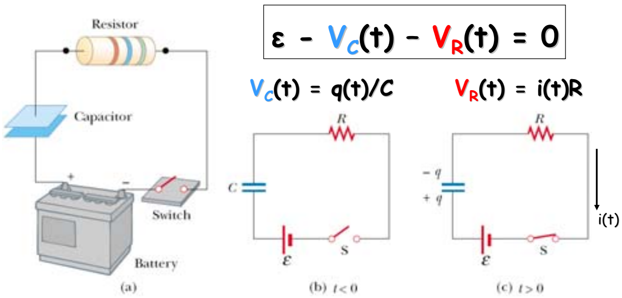
# Estado Estacionario

# Estado Transitorio

## Transitorios en circuitos RC: Carga de un Capacitor

$\boxed{\varepsilon - V_C(t) - V_R(t) = 0}$

$V_C(t) = q(t)/C$ $\quad V_R(t) = i(t)R$




$\varepsilon - q(t)/C - i(t)R = 0 \qquad i(t) = dq(t)/dt$

$\boxed{\varepsilon - q(t)/C - Rdq(t)/dt = 0}$

$\boxed{\varepsilon - q(t)/C - Rdq(t)/dt = 0}$

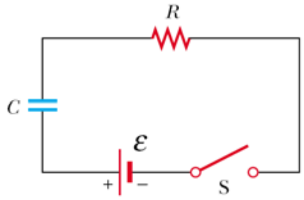
$\boxed{q(t) = \varepsilon C(1-e^{-t/(RC)})}$

$\boxed{q(t) = Q_{Máx}(1-e^{-t/\tau}) \quad Q_{Máx}=\varepsilon C}$ $\quad \boxed{\tau = RC}$

$\boxed{V_C(t) = (Q_{Máx}/C)(1-e^{-t/\tau}) = \varepsilon(1-e^{-t/\tau})}$

$i(t) = dq(t)/dt$

$\boxed{i(t) = I_{Máx}e^{-t/\tau} = (\varepsilon/R)\, e^{-t/\tau}}$




**Ejemplo:**

$\varepsilon = 12$ V

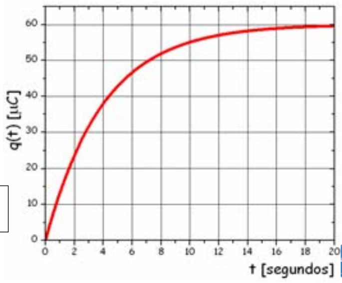
R= 800 kΩ = 8x10⁵ Ω

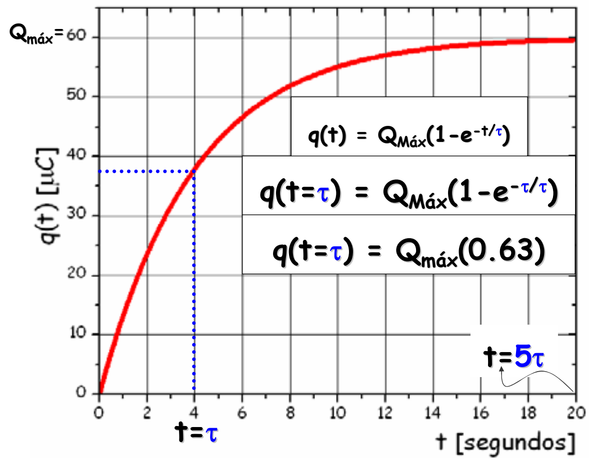
$C = 5\ \mu F = 5\times10^{-6} F$

$Q_{máx} = \varepsilon C = (12V)(5\times10^{-6}\mu F) = 60\times10^{-6} C = 60\mu C$

$\tau = RC = (8\times10^{5}\Omega)(5\times10^{-6}\mu F) = 4s$

$q(t) = 60(1-e^{-t/4})$ [mC]

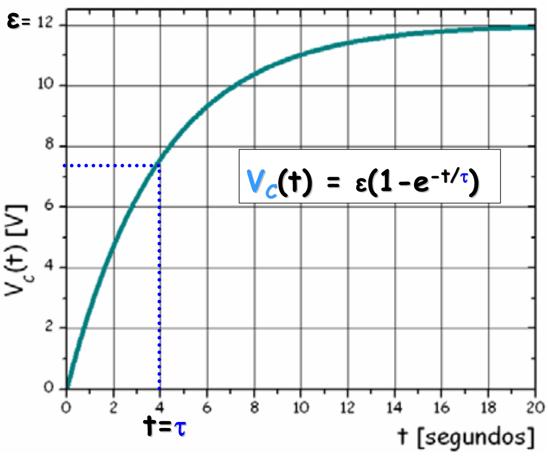


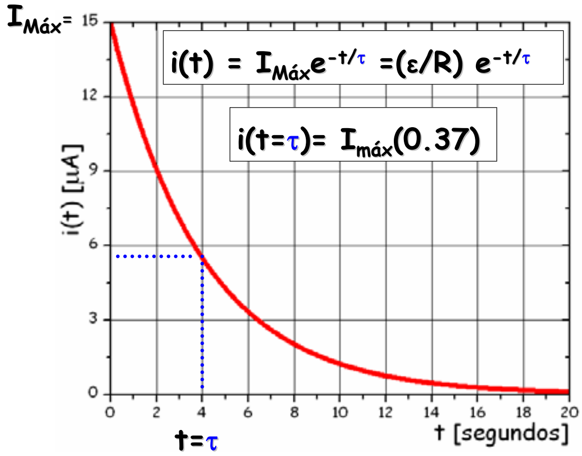

$q(t) = Q_{Máx}(1-e^{-t/\tau})$

$q(t=\tau) = Q_{Máx}(1-e^{-\tau/\tau})$

$q(t=\tau) = Q_{máx}(0.63)$

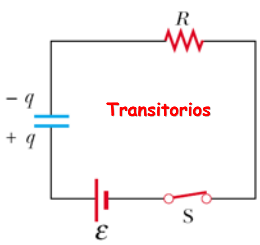


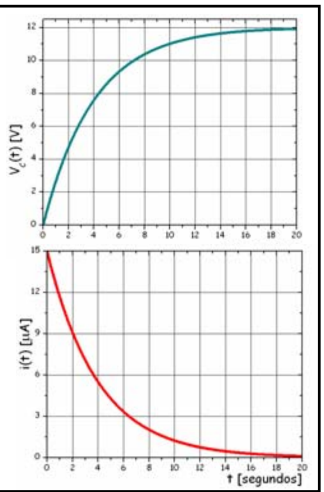

$V_C(t) = \varepsilon(1-e^{-t/\tau})$

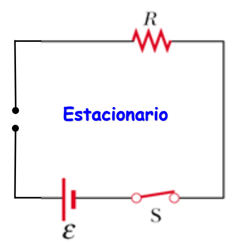


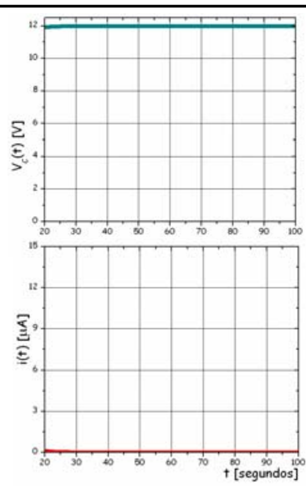

$i(t) = I_{Máx}e^{-t/\tau} = (\varepsilon/R)\, e^{-t/\tau}$

$i(t=\tau) = I_{máx}(0.37)$



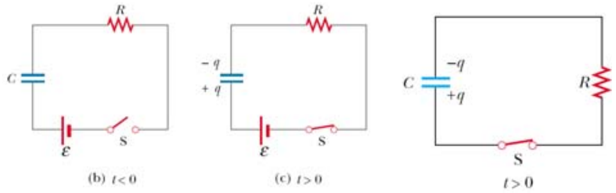



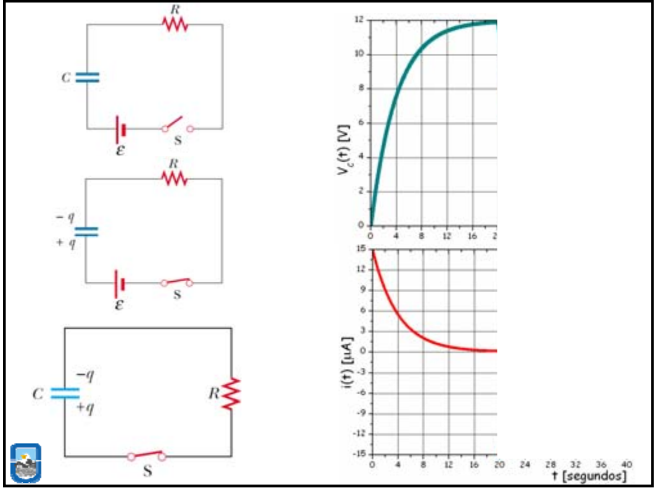
## Transitorios en circuitos RC: Descarga de un Capacitor

$$- q(t)/C - i(t)R = 0$$




$$-q(t)/C - R\,dq(t)/dt = 0 \qquad q(t) = Q_{Máx}(e^{-t/\tau})$$

$$V_C(t) = \varepsilon e^{-t/\tau} \qquad i(t) = -I_{Máx}e^{-t/\tau}$$




# Resumen: Inductores y Capacitores

**R, L y C sólo dependen de factores geométricos y del material. No Dependen ni de V ni de I ni de q**

$$i(t)=(V_0/R)(1-e^{-t/\tau}) \qquad i(t)=(V_0/R)e^{-t/\tau}$$

$$V_L(t)=V_0e^{-t/\tau} \qquad V_L(t)=-V_0e^{-t/\tau}$$

$$\tau = L/R$$

$$i(t)=(V_0/R)e^{-t/\tau} \qquad i(t)=-(V_0/R)e^{-t/\tau}$$

$$V_C(t)=V_0(1-e^{-t/\tau}) \qquad V_C(t)=V_0e^{-t/\tau}$$

$$\tau = RC$$

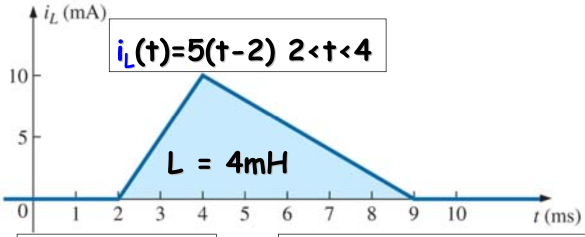
Estado Transitorio.

$$I = \frac{V_R}{R} \qquad V_R = IR$$

$$i_L(t) = \frac{1}{L}\int_{t=0}^{t=t} v_L(t)dt \qquad v_L(t) = L\frac{di(t)}{dt}$$

$$i_C(t) = C\frac{dv_C(t)}{dt} \qquad v_C(t) = \frac{1}{C}\int_{t=0}^{t=t} i_C(t)dt$$

Válidas para todo tiempo




$i_L(t)=5(t-2)$ $2<t<4$

L = 4mH

$i_L(t)=0$ $0<t<2$

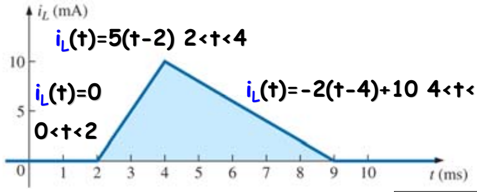
$i_L(t)=-2(t-4)+10$ $4<t<10$

$$v_L(t) = L\frac{di(t)}{dt}$$

$v_L(t)=L5$ $2<t<4$

$v_L(t)=-L2$ $4<t<10$

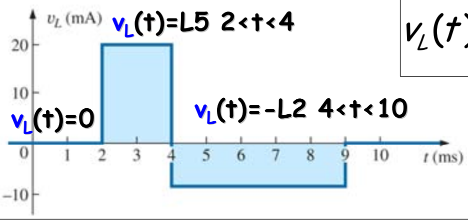
**Ejemplo**




$i_L(t)=5(t-2)$ $2<t<4$

$i_L(t)=0$
$0<t<2$

$i_L(t)=-2(t-4)+10$ $4<t<10$




$v_L(t)=L5$ $2<t<4$

$$v_L(t) = L\frac{di(t)}{dt}$$

$v_L(t)=0$

$v_L(t)=-L2$ $4<t<10$