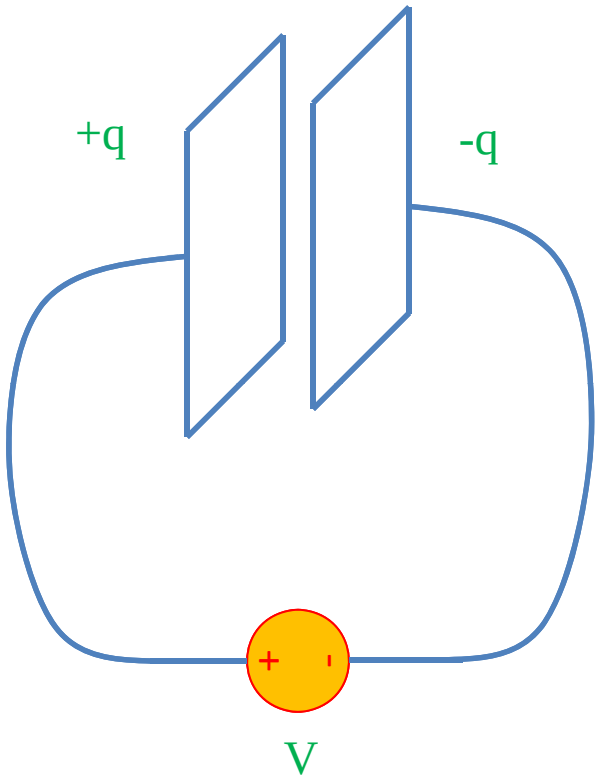
Announcements:

1. PSpice is installed in ECT 123 and EH 1131.

# EECS 70A: Network Analysis

## Lecture 10

# Capacitors




$$q = CV$$

$$C = \frac{\varepsilon A}{d}$$

A=area
d=plate separation

Farads[F] = Coulombs/Volt [C]/[V]

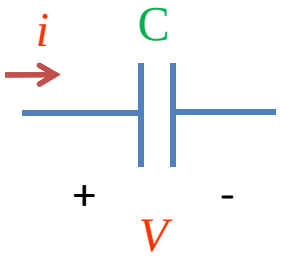
$$\varepsilon_0 = 8.85 \times 10^{-12}\, F/m$$

$$\varepsilon = \kappa \varepsilon_0$$

Dielectric constant:

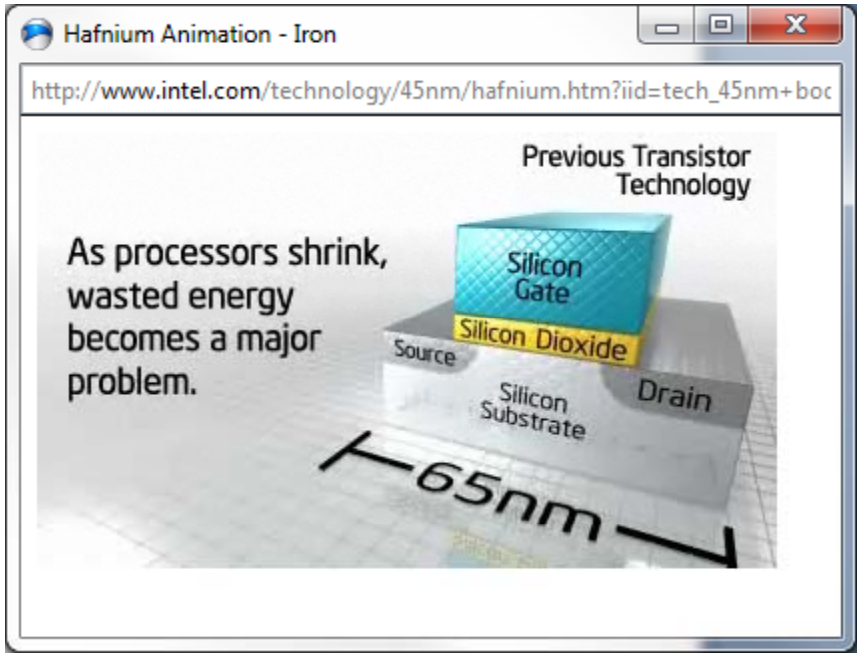
$\kappa = 3.9$ $SiO_2$

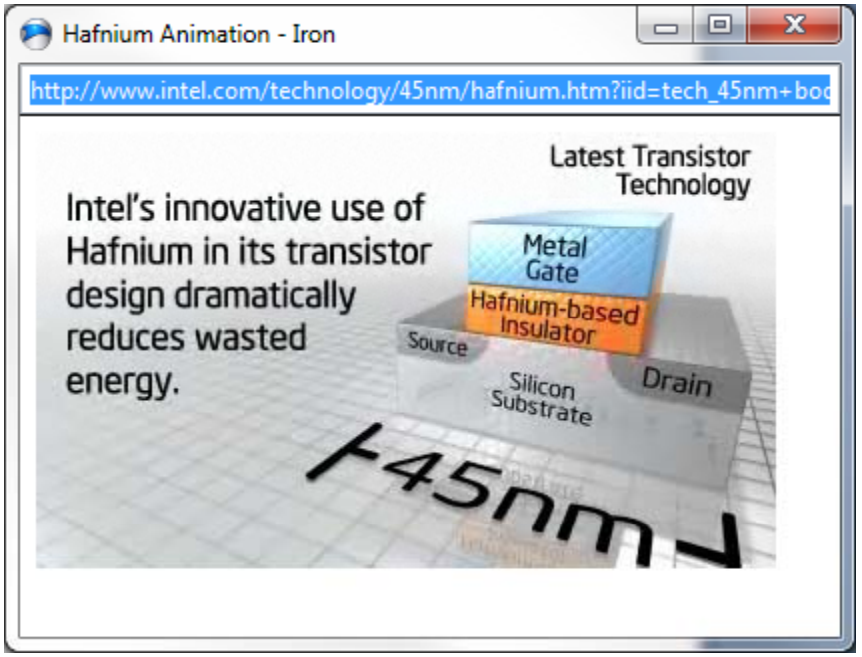
$\kappa = 25$ $HfO_2$



# “High-K Dielectric”

http://www.intel.com/technology/45nm/hafnium.htm?iid=tech_45nm+body_animation_hafnium



# Time dependence

$$q = CV \qquad i = \frac{dq}{dt} = C\frac{dV}{dt}$$

*q, V, i can depend on time !*

Implicit:

$$q(t) = CV(t) \qquad i(t) = \frac{dq(t)}{dt} = C\frac{dV(t)}{dt}$$

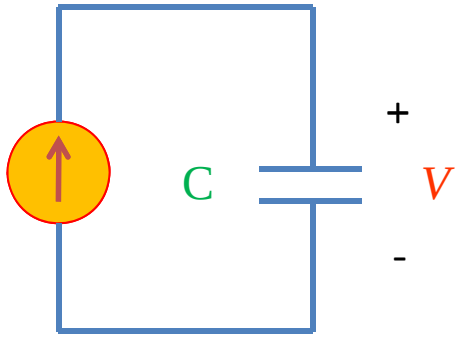
Will not always write (t), but it is assumed from now on.

$$i(t) = C\frac{dV(t)}{dt} \Rightarrow V(t) = \frac{1}{C}\int i(t)dt$$

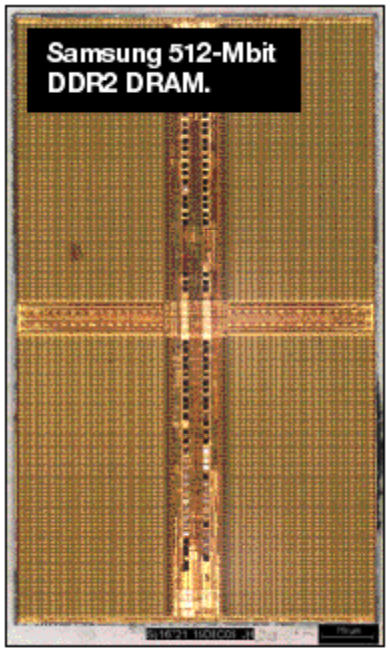
$$\Rightarrow q(t) = \int i(t)dt$$

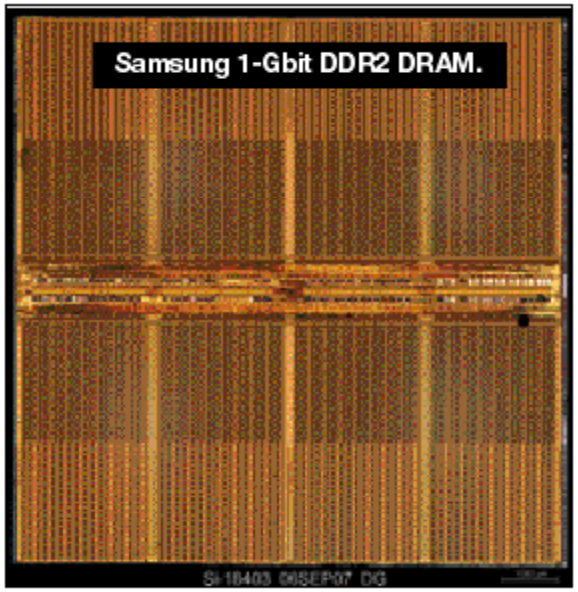
# Example Capacitor Problem

Find V(t), q(t)



# One-bit memory

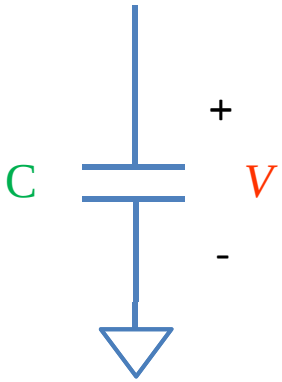



Typical dimensions:
0.1 micron x 0.1 micron area
10 nm thickness.
What is C?

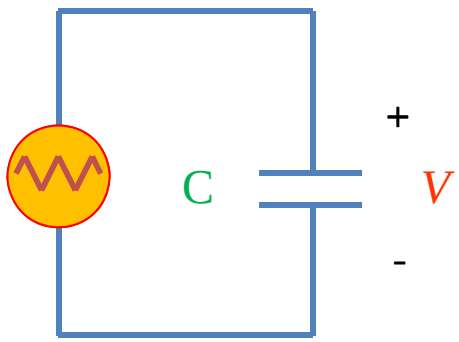
http://i.cmpnet.com/eet/news/07/11/DC1502_UTH_samsung.gif

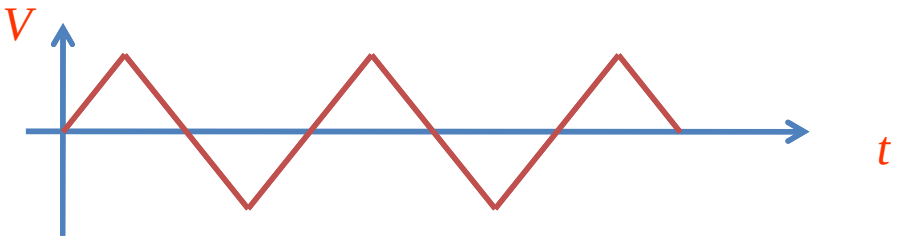
# 1 Bit Read/Write



# Example Problem #2

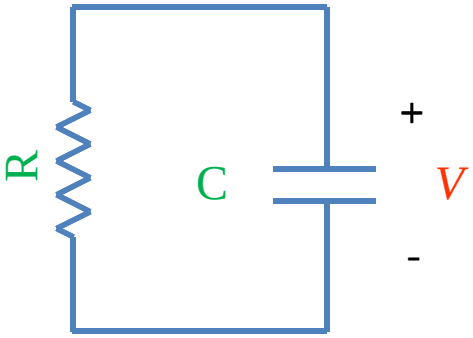
(Students): Find i(t), q(t)



# RC circuit

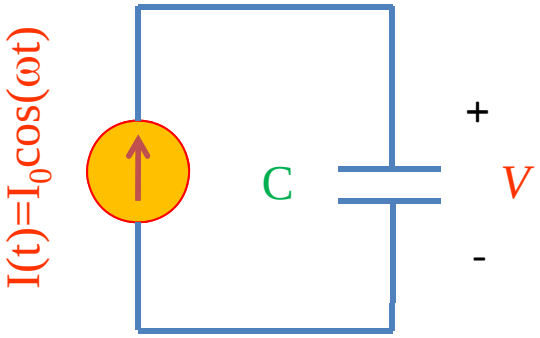
Find V(t), q(t), i(t)



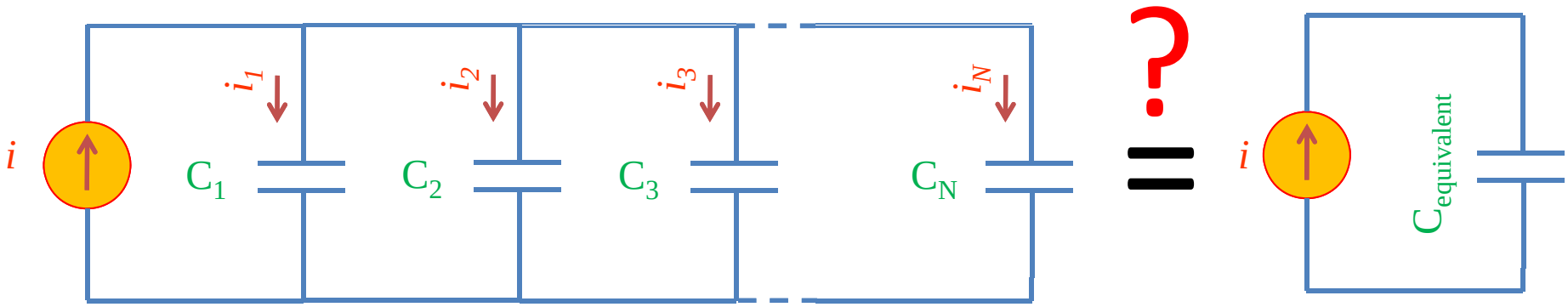
# DRAM vs. SRAM

# Example Capacitor Problem #2

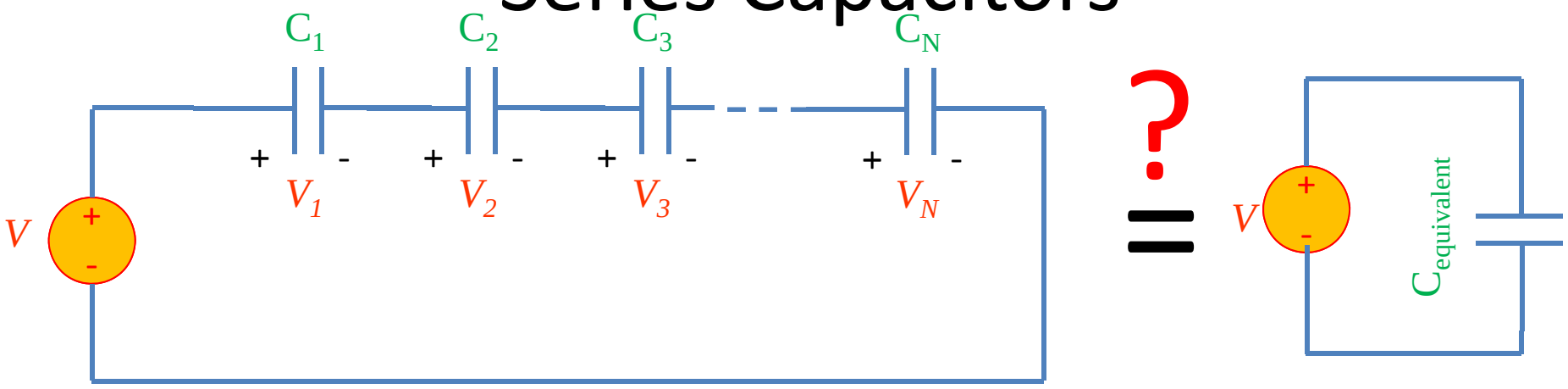
Find V(t), q(t)



# Parallel Capacitors

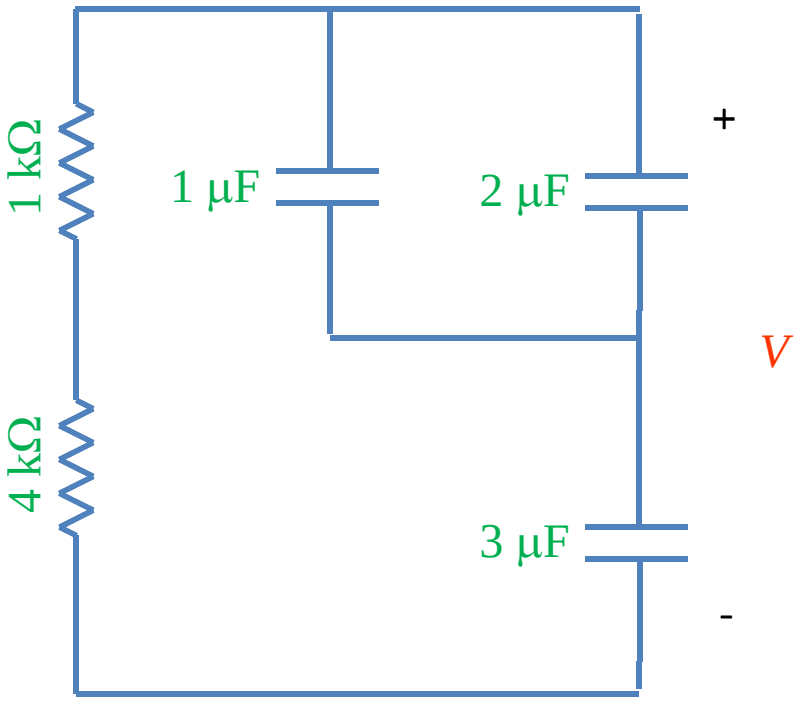


# Series Capacitors

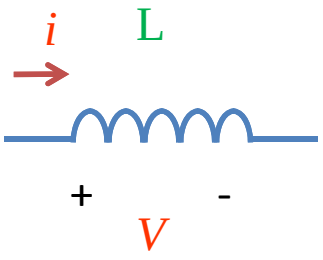


# Example problem #4

(Students) Find V(t), given that V(t=0) = 5 Volts



# Inductors




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

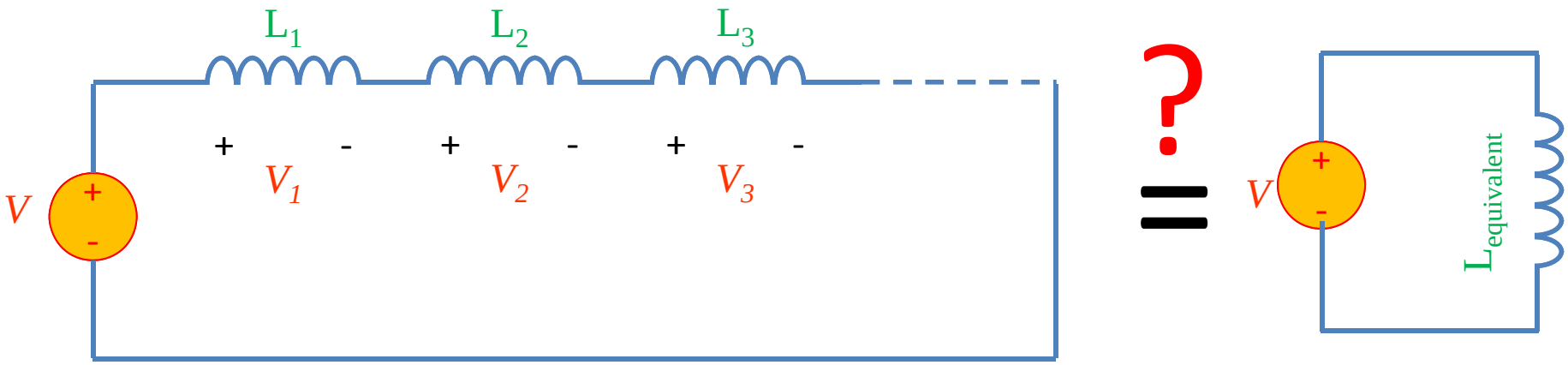
A=area
l=wire length
N = # of turns
$\mu = 4\ \pi\ 10^{-6}$ H/m

$$V = L\frac{di}{dt}$$

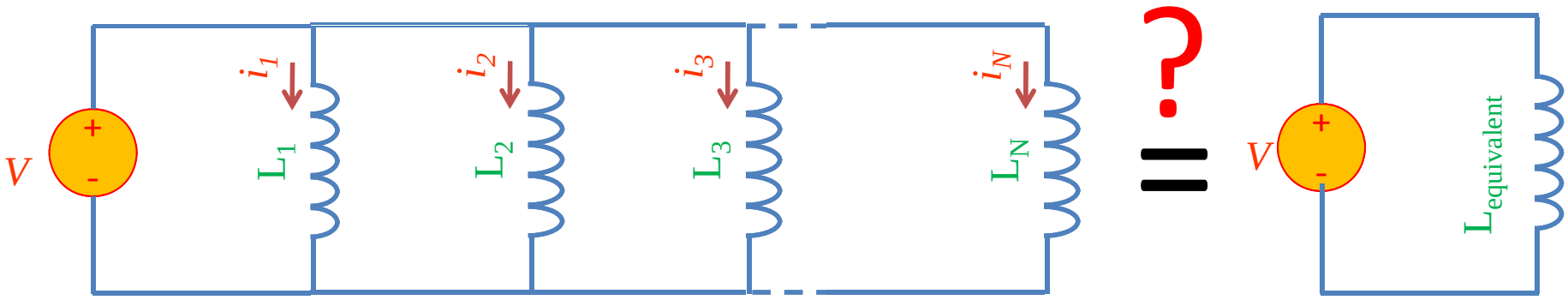
Henry[H]

$$V = L\frac{di}{dt} \Rightarrow i(t) = \frac{1}{L}\int V(t)dt$$

# Series Inductors

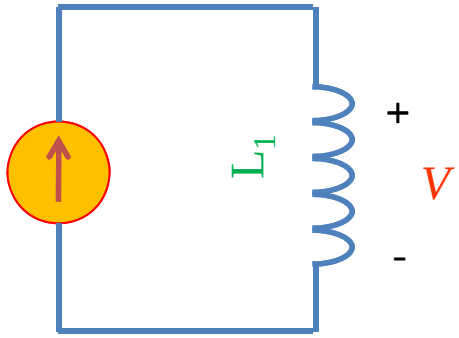


# Parallel Inductors



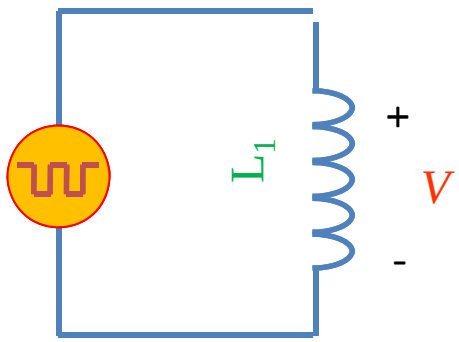
# Example Inductor Problem

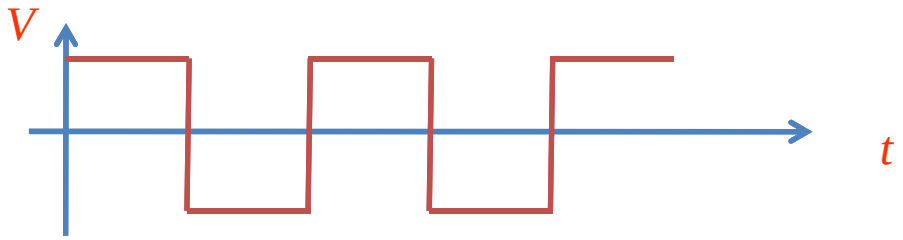
(Students): Find V(t).



# Example Inductor Problem #2

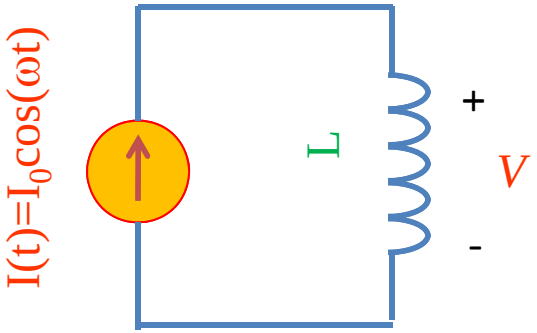
(Students): Find i(t)



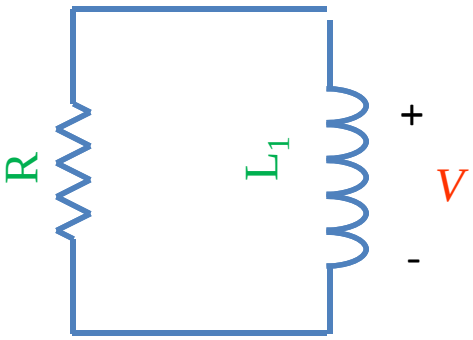
# Example Inductor Problem #3

Find V(t)



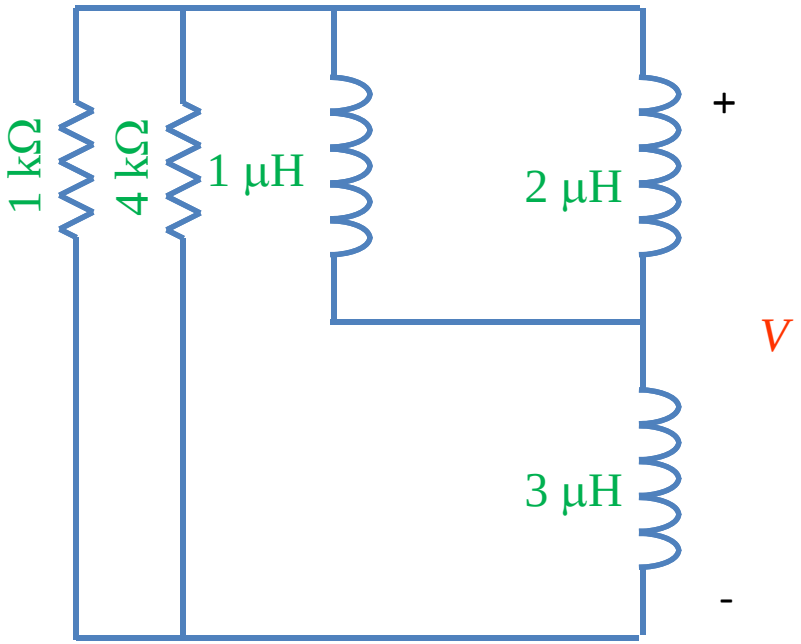
# LR circuit

Find V(t), i(t)

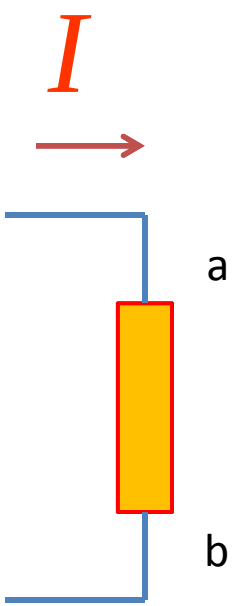


# Example LR problem

(Students) Find V(t), given that V(t=0) = 5 Volts



# Power




$$I \; x \; V_{ab} = power$$

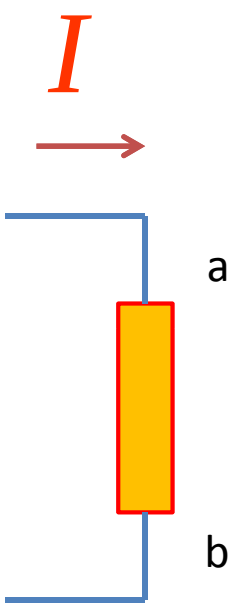
Watts [W] = Volt Amp [V-A]

Note: MKSA unit system:
*Meters Kilogram Second Amp*

Resistor:
Energy lost to heat…

Inductor or capacitor:
Energy *STORED* and can be recovered…

# Energy stored




$$I \; x \; V_{ab} = power$$

Energy:

$$W = \int P dt = \int I \cdot V dt$$

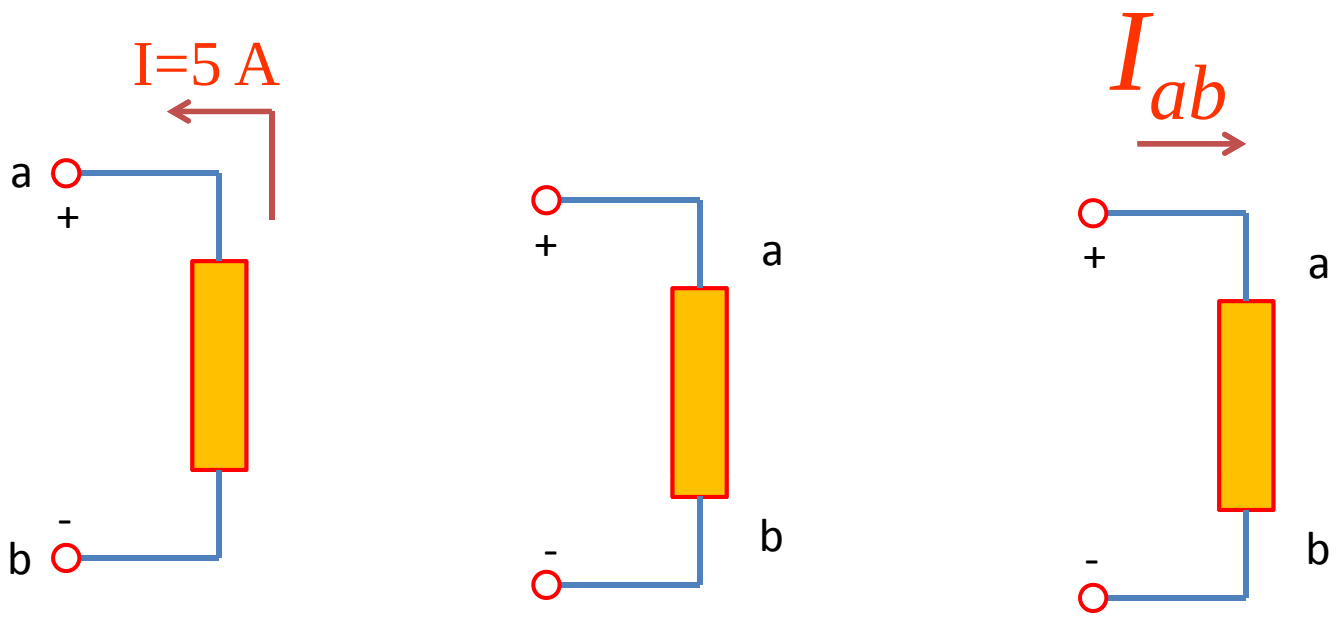
Capacitor stored energy:

$$\int I \cdot V dt = \int C \frac{dV}{dt} \cdot V dt = \frac{1}{2} C V^2 = \frac{Q^2}{2C}$$

Inductor stored energy:

$$\int I \cdot V dt = \int I \cdot L \frac{dI}{dt} dt = \frac{1}{2} L I^2$$

# Symbol library



# Symbol library