Announcements:

1. Final HW due Friday of 10th week
2. Professor Burke's office hours this week:
   Tu 9:30-11:30 (EH 2230)
   Th 9:30-11 (EG 2232)
   Th 2-3:30 (EH 2230)
3. Exam :
   - Will cover all of Chs. 1,2,3,4,6, 7.1-7.3, 9 (not delta-Y), 14.1 14.2 14.3 14.5 14.6 14.7
   - Not covered: 3.6, 3.8, 4.9, 6.6.
   - No calculators. We will give sin, cos, tan tables as shown on last slide of today's notes..

EECS 70A: Network Analysis

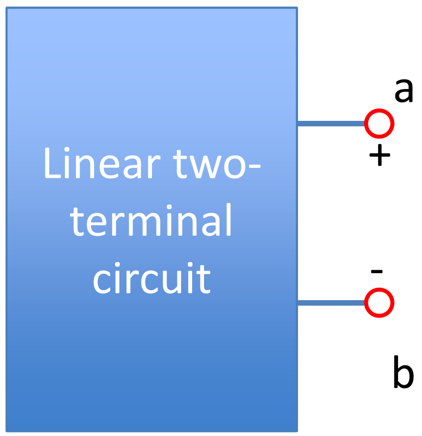
Lecture 16

Comprehensive review

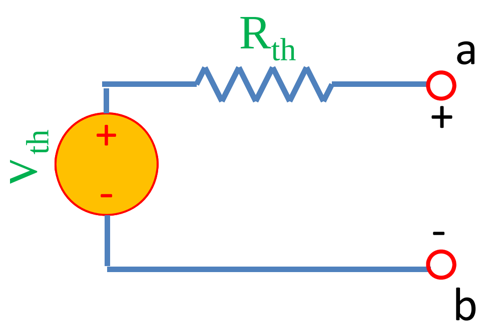
Topics covered

- KCL, KVL
- Nodal analysis
- Mesh analysis
- Thevenin/Norton theorem
- RL, RC circuits (time dependence)
- R,L,C circuits
  - Phasors
  - Impedances
  - Transfer function

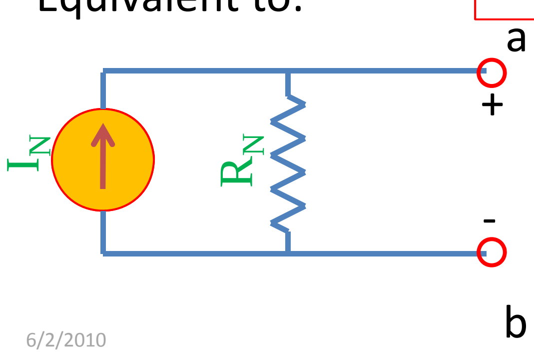
Thevenin, Norton Theorems:



Equivalent to:



Equivalent to:



Thevenin:

1. **Calculating V_{th}:**
   Connect nothing to a-b. Calculate voltage. This is V_{th}.
2. **Calculating R_{th}:**
   Method 1:
   - Connect terminal a to b (short).
   - Calculate the current from a to b. This is call $I_{short\ circuit}$.
   - $R_{th}=V_{th}/I_{short\ circuit}$.

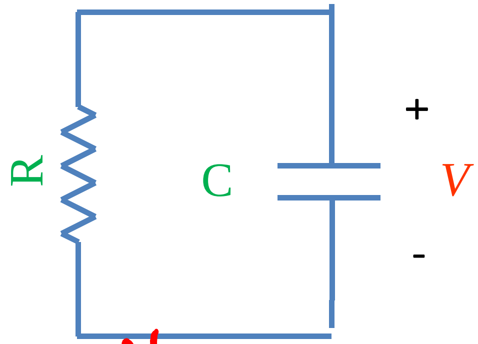
   Method 2:
   - Find the input resistance looking into terminals a-b after all the independent sources have been turned off. (Voltage sources become shorts, current sources become opens.)
   - ***Trick (if dependent sources present):***
   - Apply a 1 A current source to terminals a-b, find V_{ab}
   - $R_{th} = V_{ab}/1A$.

Norton:

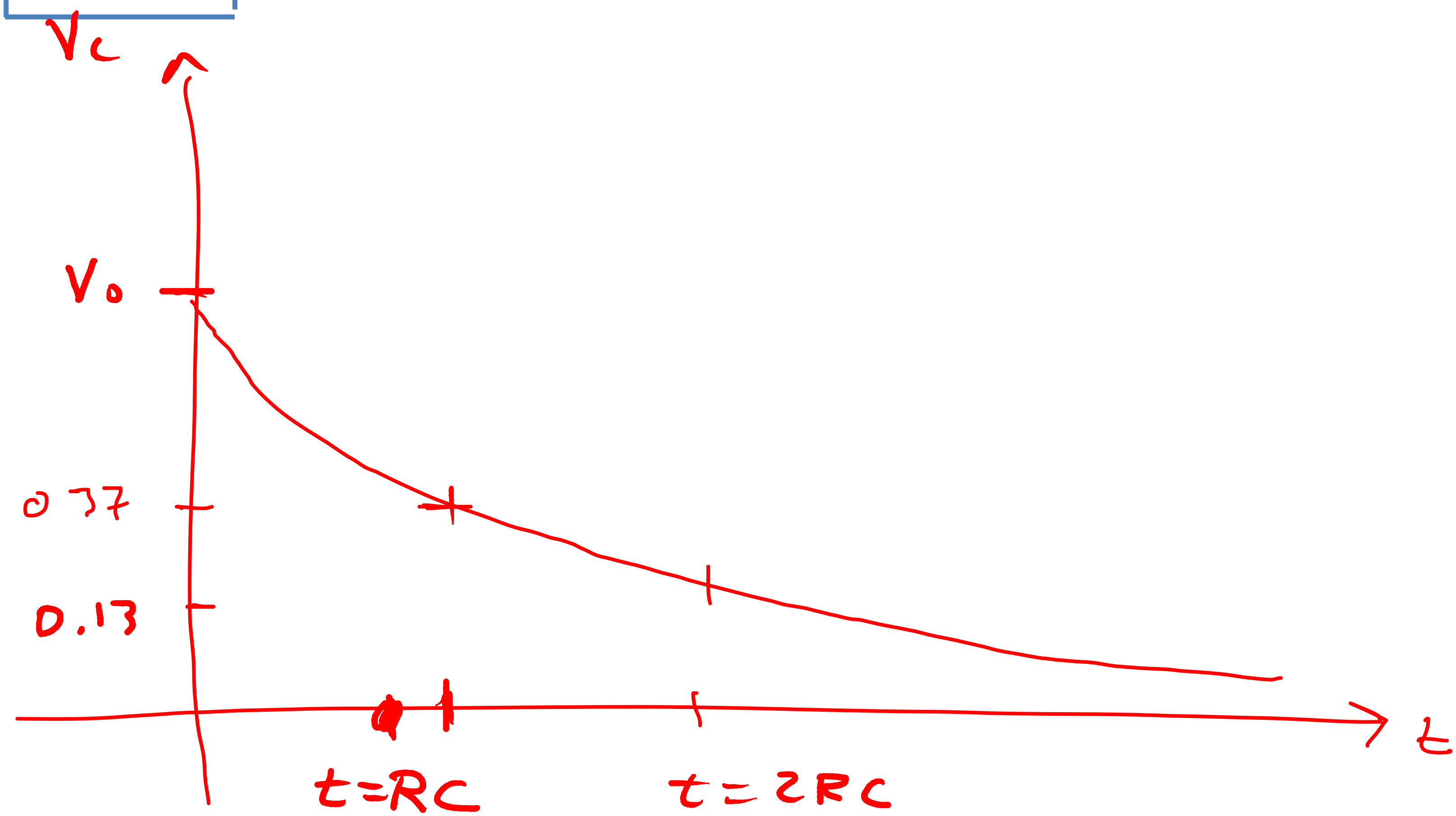
1. **Calculating R_N:**
   $R_N=R_{th}$
2. **Calculating I_N:**
   $I_N=V_{th}/R_{th}$

RC circuit

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



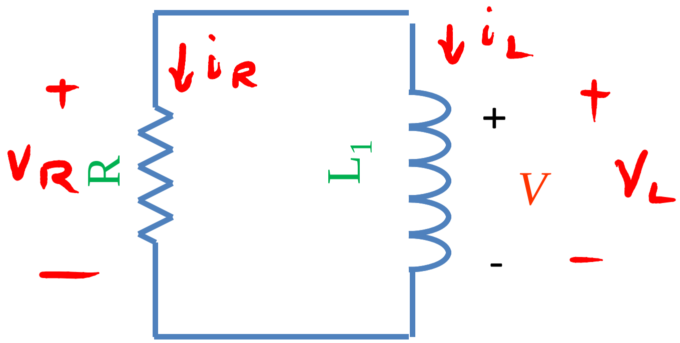
$$V(t) = V(t=0)\, e^{-t/RC}$$



LR circuit

$V_R = i_R R$

Find V(t), i(t)



$V_L = L\frac{di_L}{dt}$

KVL $\Rightarrow$ $V_L = V_R$

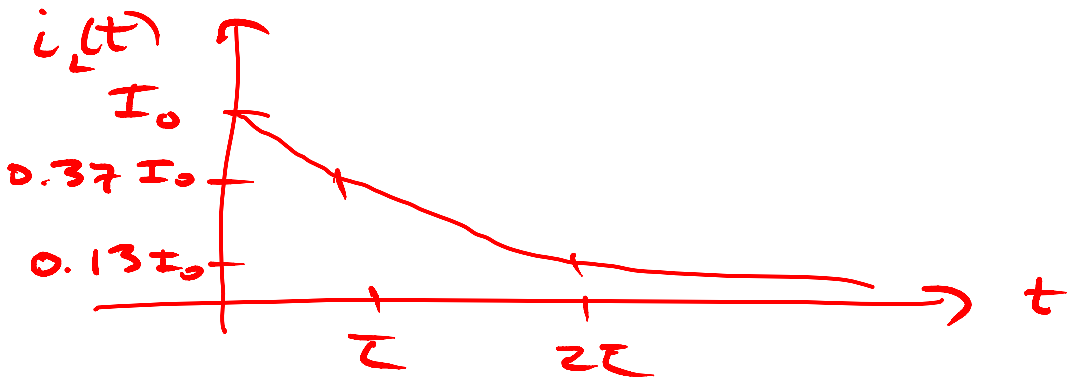
KCL $\Rightarrow$ $i_R = -i_L$

$$L\frac{di_L}{dt} = i_R R = \boxed{-i_L R = L\frac{di_L}{dt}}$$

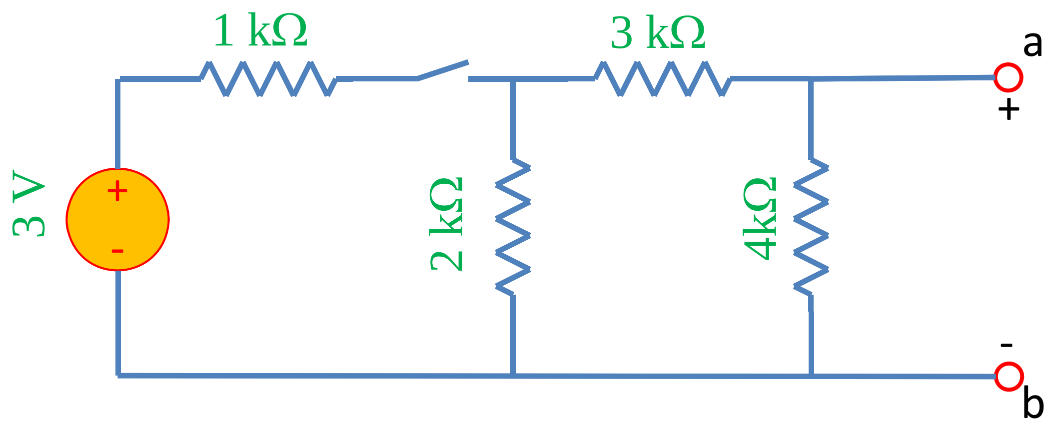
$$\Rightarrow \frac{di_L}{dt} = -\frac{1}{L/R}\, i_L$$

$\tau \equiv \frac{L}{R}$ time constant

$$i_L(t) = i_L(t=0)\, e^{-t/\tau}$$



Comprehensive Example



A) This circuit is connected to a capacitor of value 1 μF. The switch is in the closed position. After a long time, what are all the voltages and currents in this circuit?

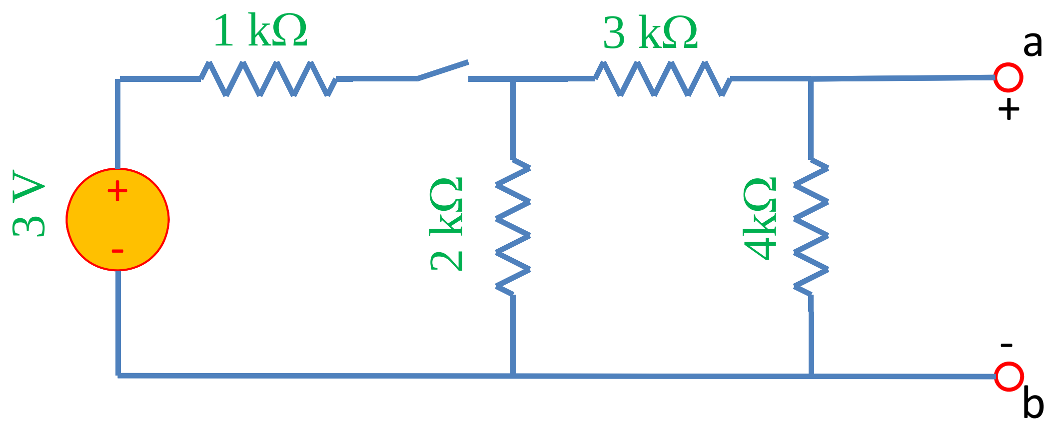
B) Next, the switch is opened.
What are all the voltages and currents in this circuit as a function of time after the switch is opened?

C) This circuit is now connected to a resistor R_0. What is the power dissipated in R_0?

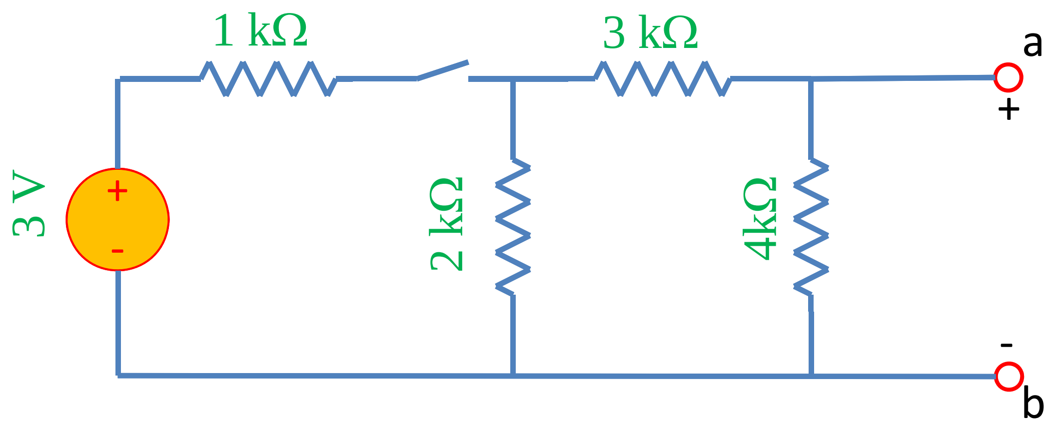
D) If you were to pick a value of R_0 to absorb as much power as possible, what would it be?

E) Exercise: Do the same as A,B with an inductor instead.

Comprehensive Example



Comprehensive Example



Conversion procedures

$\mathrm{i(t)} \rightarrow \mathbf{I}$

$\mathrm{v(t)} \rightarrow \mathbf{V}$

$\mathbf{I} \rightarrow \mathrm{i(t)}$

$\mathbf{V} \rightarrow \mathrm{v(t)}$

$$i(t) = I_m \cos(\omega t + \phi) \Rightarrow \quad \mathbf{I} = I_m e^{j\phi}$$

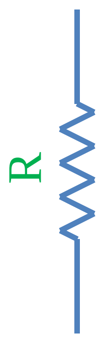
$$v(t) = V_m \cos(\omega t + \phi) \Rightarrow \quad \mathbf{V} = V_m e^{j\phi}$$

$$i(t) = \mathrm{Re}\left(\mathbf{I}\, e^{j\omega t} \right)$$

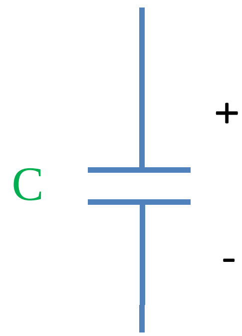
$$v(t) = \mathrm{Re}\left(\mathbf{V} e^{j\omega t} \right)$$

For the exam, you should know how to carry out these procedures.

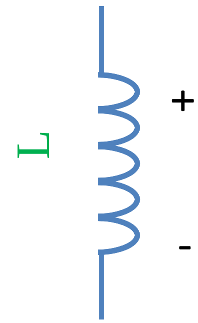
Circuits



$\mathbf{V} = \mathbf{I}\,R$



$\mathbf{V} = \mathbf{I}/j\omega C$



$\mathbf{V} = j\omega L\,\mathbf{I}$

"Impedance"

$Z = R$ $\qquad$ $Z = 1/j\omega C$ $\qquad$ $Z = j\omega L$

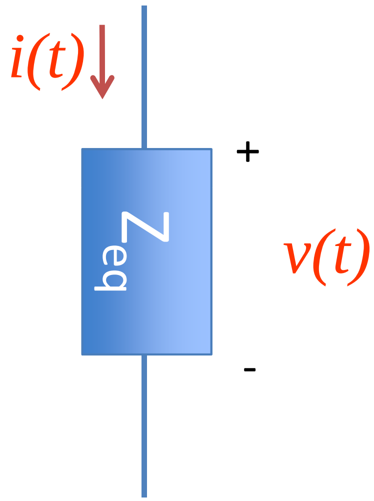
KCL, KVL hold for relationship between **V**, **I**.

Series/Parallel Impedances

$$Z_{eq} = Z_1 + Z_2 + Z_3$$

$$Z_{eq}^{-1} = Z_1^{-1} + Z_2^{-1} + Z_3^{-1}$$

Conversion procedures



Given i(t) find v(t):

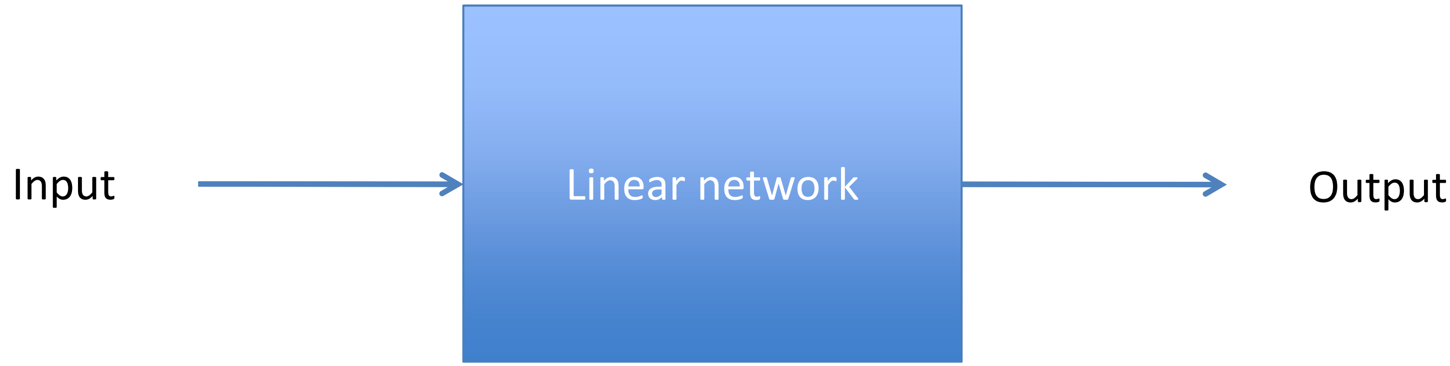
$$i(t) \rightarrow \mathbf{I} \rightarrow \mathbf{V} = \mathbf{I}\, Z_{eq} \rightarrow v(t)$$

Given v(t) find i(t):

$$v(t) \rightarrow \mathbf{V} \rightarrow \mathbf{I} = \mathbf{V}/\, Z_{eq} \rightarrow i(t)$$

For the exam, you should know how to carry out these procedures.

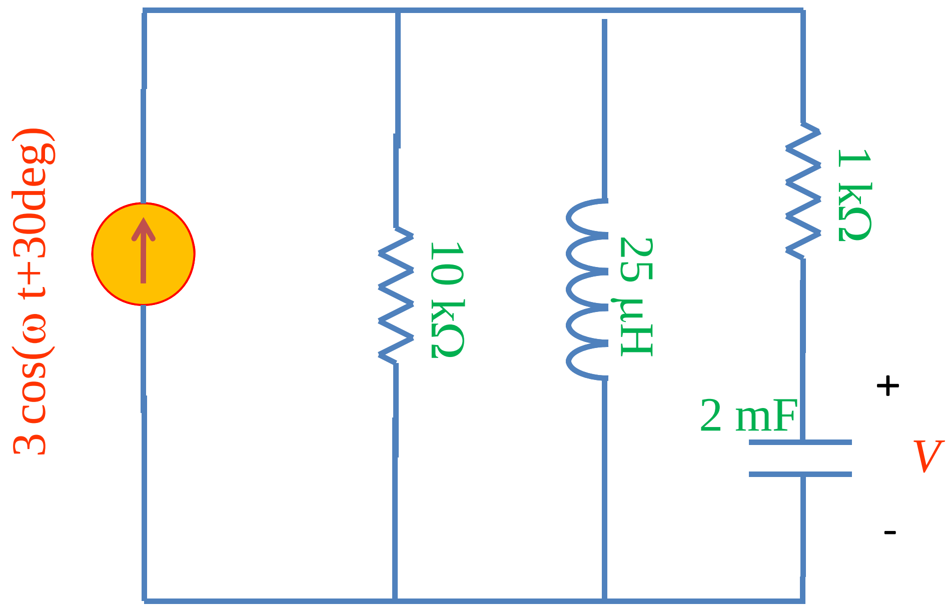
"Transfer Function"



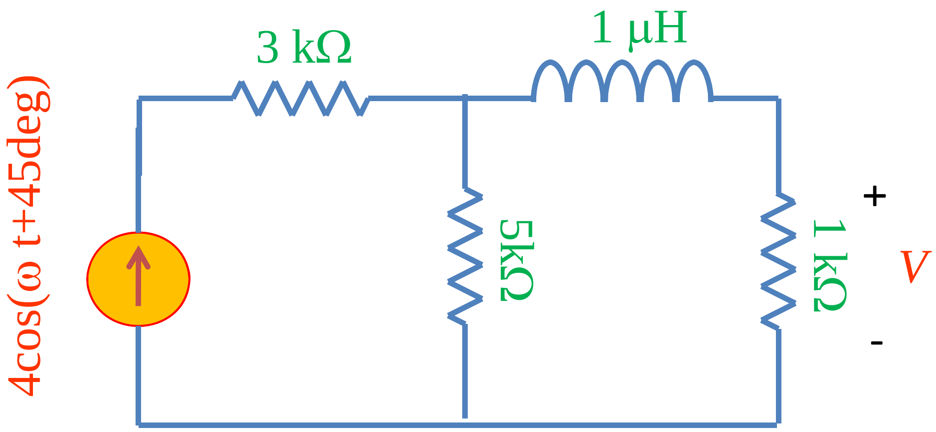
$$H(\omega) = \mathbf{V_{out}/V_{in}}$$

Phasor Example 1

Find v(t).

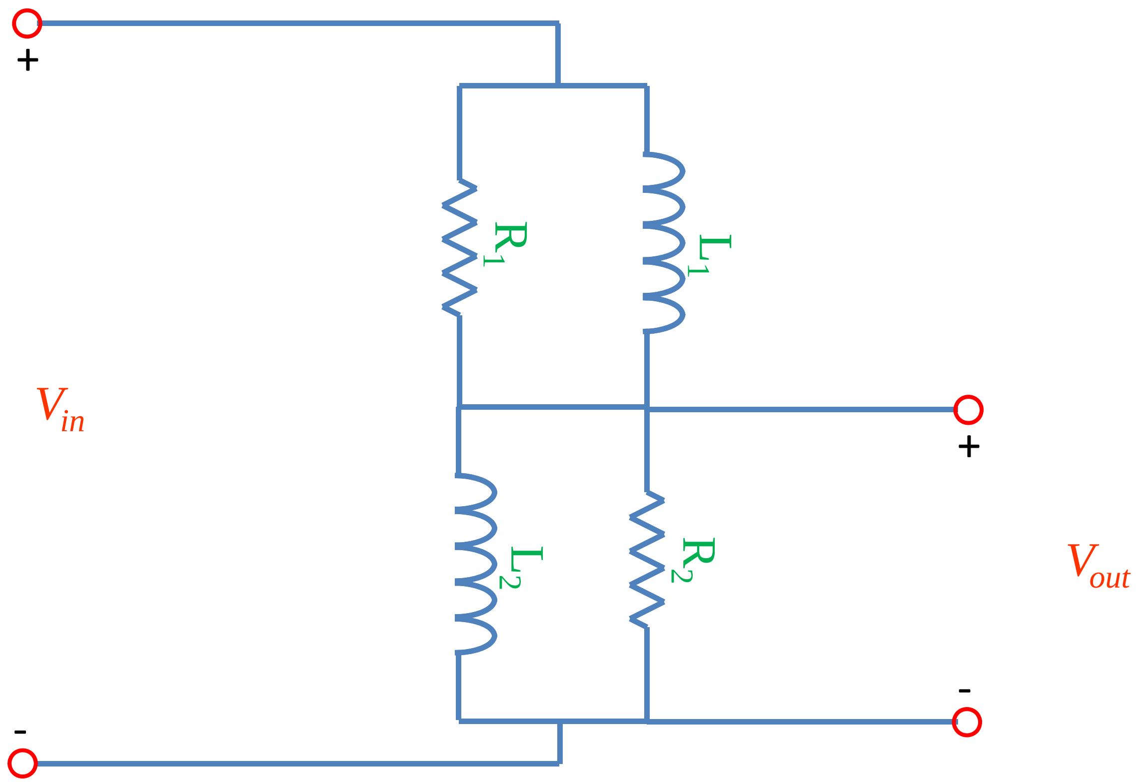


Phasor Example 2



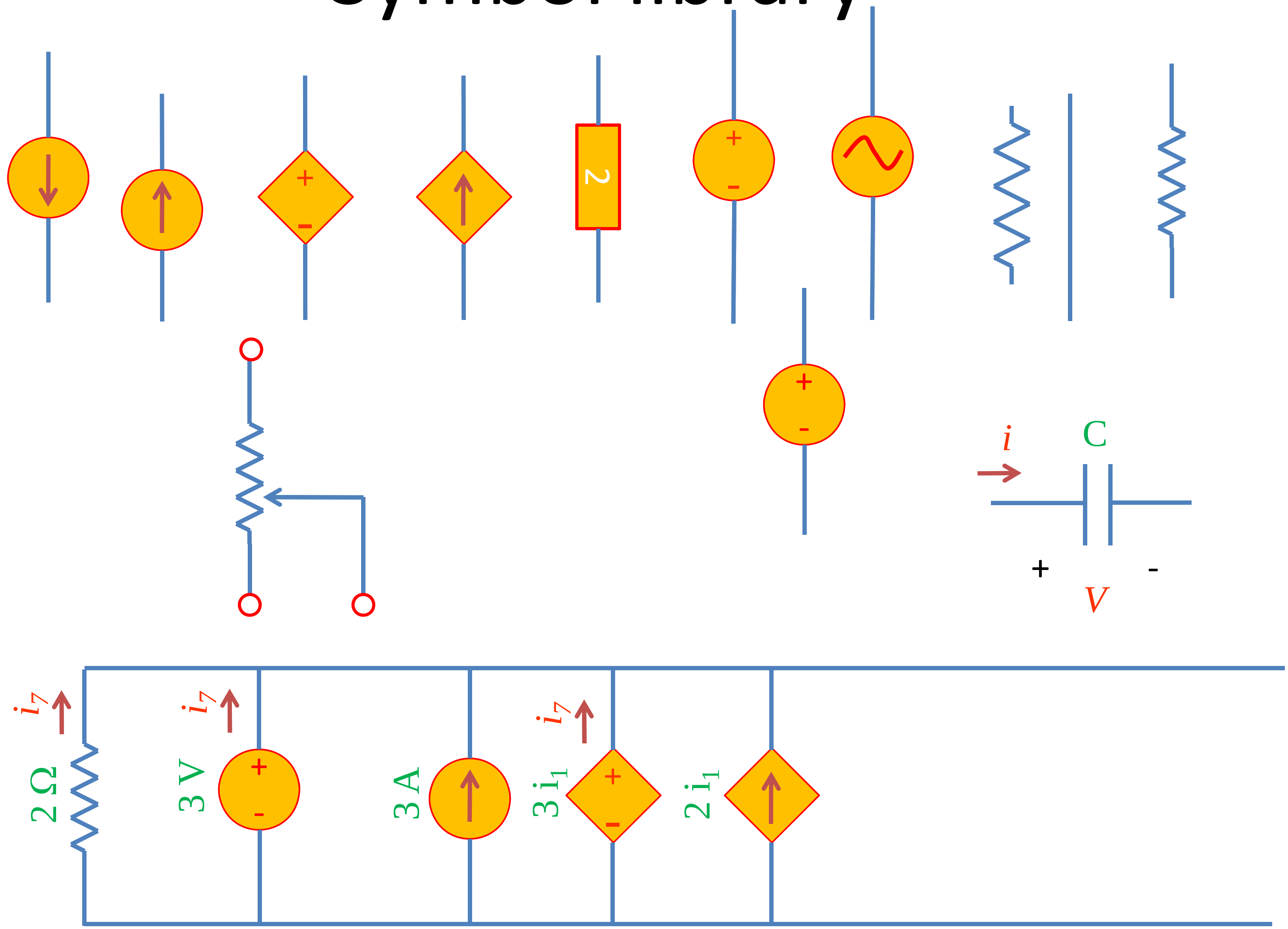
Find v(t).

Example Transfer function



Calculate H(ω) for this circuit. Sketch the magnitude of H(ω) vs. ω.

Symbol library



Exam cheat sheet

This will be provided with the exam.

radians :	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	π
sin	$\frac{\sqrt{0}}{2}$	$\frac{\sqrt{1}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{4}}{2}$	0
cos	$\frac{\sqrt{4}}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{1}}{2}$	$\frac{\sqrt{0}}{2}$	-1
tan	$\frac{\sqrt{0}}{\sqrt{4}}$	$\frac{\sqrt{1}}{\sqrt{3}}$	$\frac{\sqrt{2}}{\sqrt{2}}$	$\frac{\sqrt{3}}{\sqrt{1}}$	DNE	0

where $\sqrt{\cdot}$ always denotes the positive square root, and DNE means does not exist.