

Announcements:

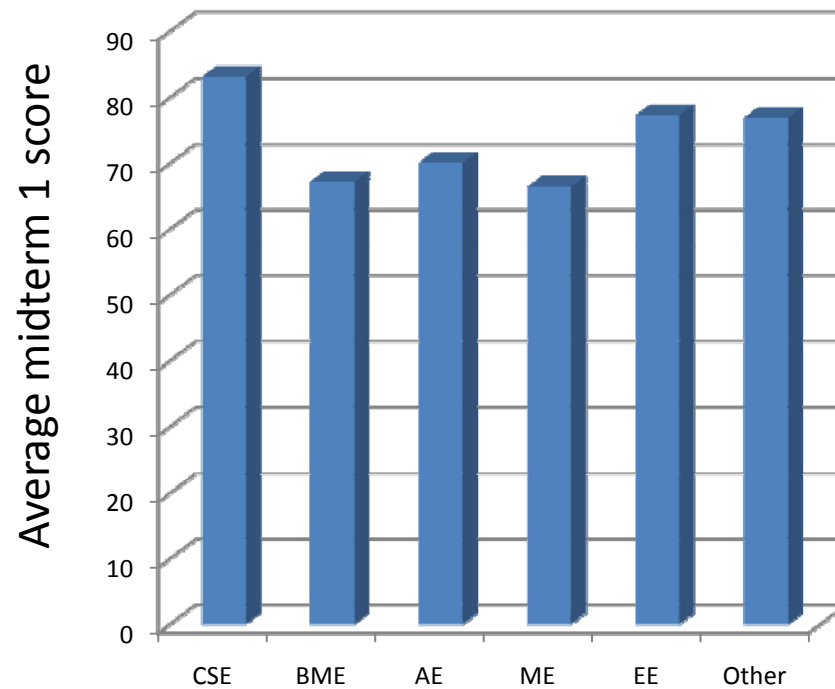
1. Final HW will be due Friday of 10th week
2. Final quiz will be due Monday of 10th week

EECS 70A: Network Analysis

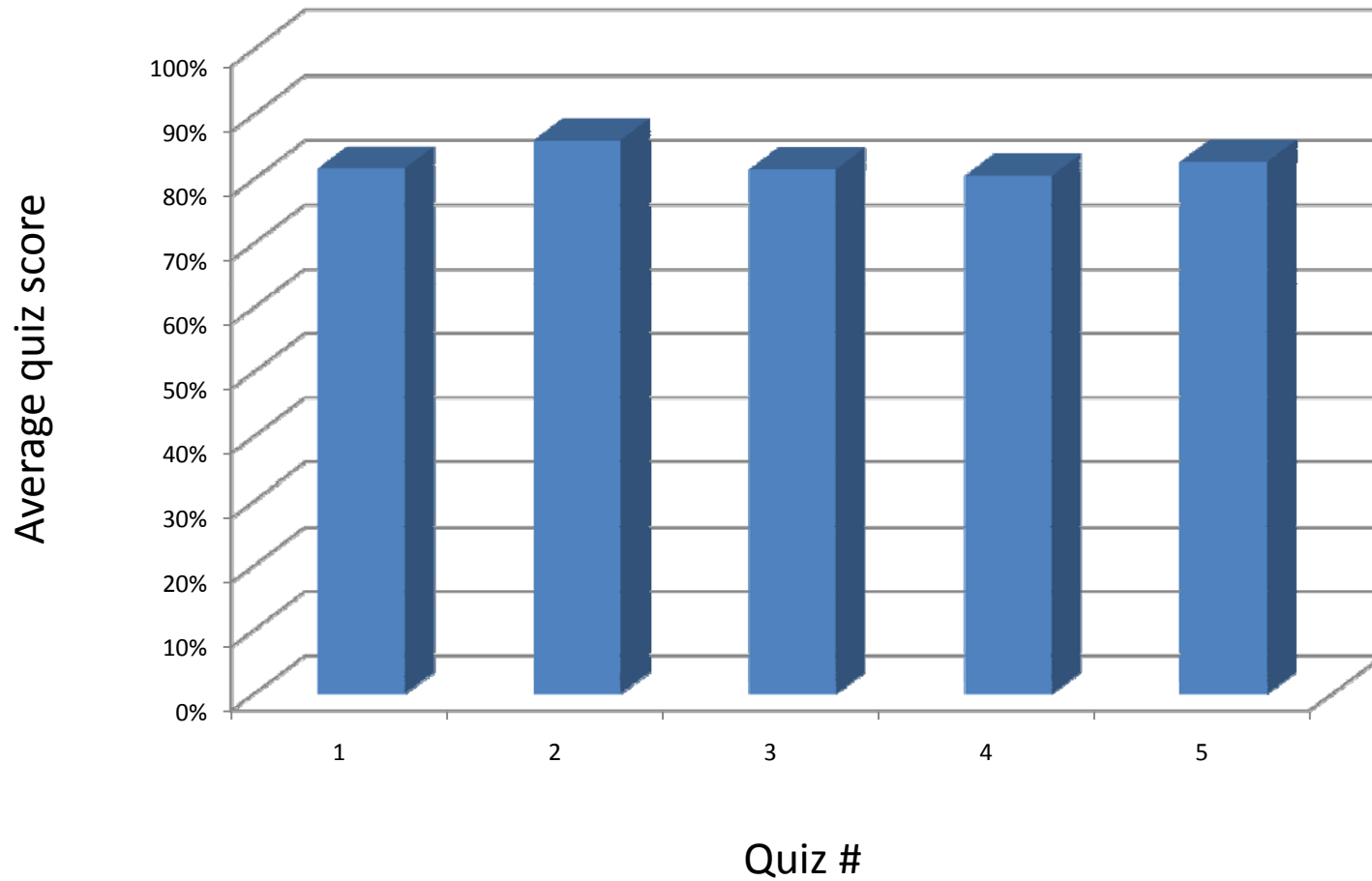
Lecture 14

“Pep Talk”

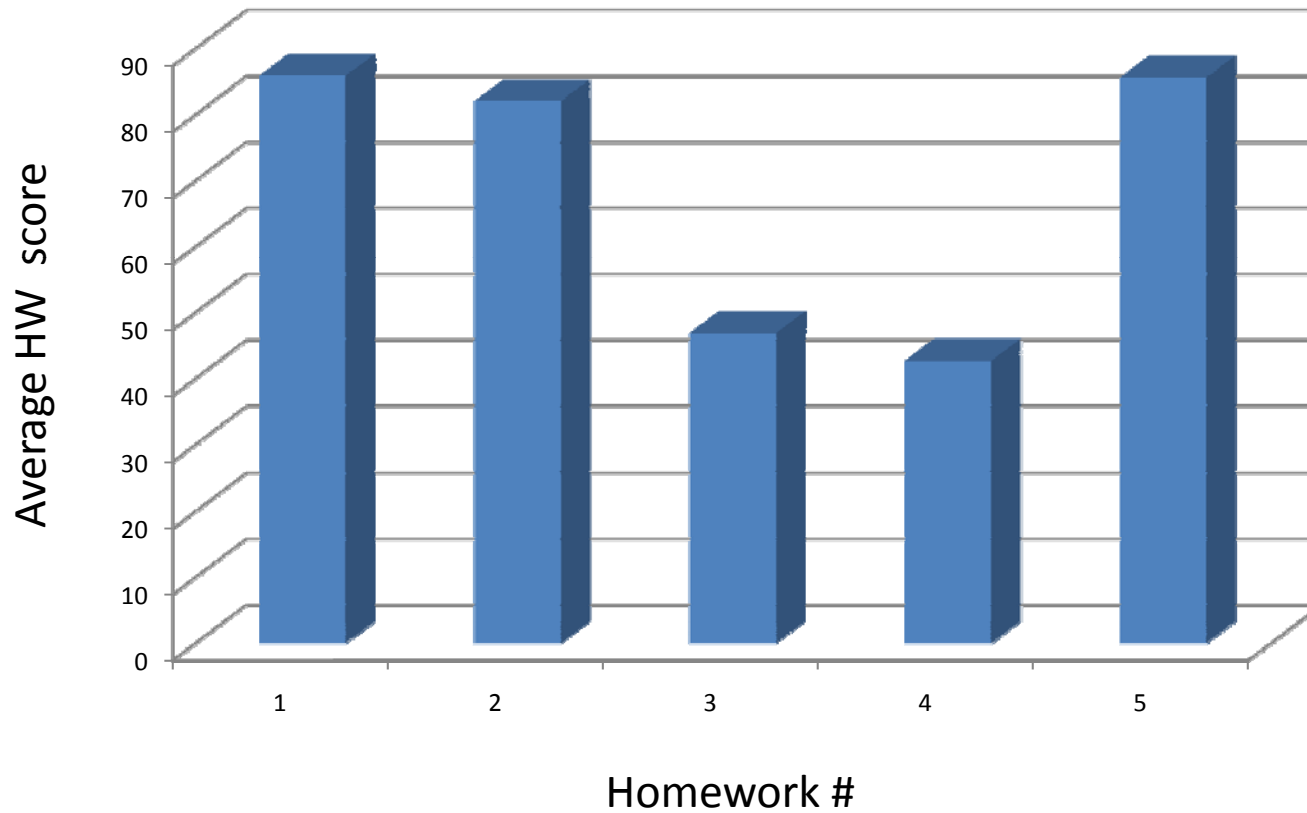
Midterm 1 averages by Major



Quiz results



HW results



Reader comments

Homework #3

There are 37 students didn't hand in their HW, which causes the mean score is around 46 this time. To those students who hand in their HW, the mean score is 62, much better.

I think HW3 is too difficult to lots of students in the class. The most difficult problem is Problem 3 because it seems no one can find the right power supplied by the independent current source. Problem 6,9,11 are also hard to them especially they're related to calculation. So I hope you can ask TA to help students work out these kinds of problems.

37 students didn't hand in HW, and around 10 students only tried to solve 2 or 3 problems from the total 11 problems in the HW. I think this isn't a good signal. Maybe you can assign more basic problems to them next time

Homework #4

There are 40 students didn't hand in their HW, which causes the mean score is around 43 this time. To those students who handed in their HW, the mean score is 59.

I think HW4 is difficult in some points. Like in Problem 2, few students worked out the relationship between V_0 and I_0 . In Problem 3, almost no student figured out the right I_n . In 4, very few students got the right maximum power although lots of students found the value for α be 0. Only 1 student got the right answer about the maximum power in Problem 5. Problem 10 and 11 are also difficult to them.

They do well in Problem 1,6,7,8 and 9.

Homework #5

This time only 16 students didn't hand in their HWs, and the mean score is around 86. To those students who handed in their HW, the mean score is higher than 95.

I think HW5 is easier than the previous two hws. Most students understand how to calculate Z_{eq} from inductors and capacitors.

Extra office hours!

Professor Burke, will be holding EXTRA office hours in: Engineering Hall, Room 2203.

Thursdays 2 pm to 3:30pm

He will be holding a tutorial then on how to manipulate complex numbers and convert from phasors to time dependent voltages and currents.

*Goals rest of quarter:
Understand these knobs!*



<http://www.peachparts.com/shopforum/showthread.php?t=256624>

Phasors

Use Euler

$$e^{j\theta} = \cos\theta + j\sin\theta$$

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

$$\mathbf{V} = V_m e^{j\phi}$$

Voltage phasor: complex #

$$i(t) = \text{Re}(\mathbf{I} e^{j\omega t})$$

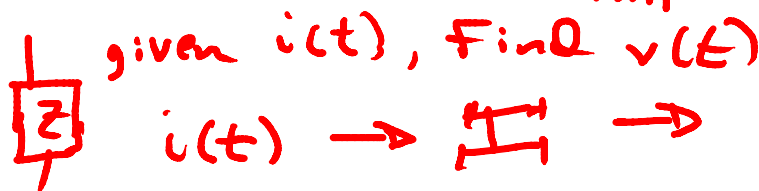
Current phasor

$$\mathbf{V} = \mathbf{I} \mathbf{Z}$$



Approach:

KIND 1



impedance

$$i(t) \rightarrow \mathbf{I} \rightarrow \mathbf{V} = \mathbf{I} \mathbf{Z} \rightarrow v(t)$$

KIND 2

given $v(t) \rightarrow \mathbf{V} \rightarrow \mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}} \rightarrow i(t)$

Example problem #3

Find $i(t)$, $V_1(t)$, $V_2(t)$ for this circuit: (instructor)

$V(t) = V_0 \cos(\omega t)$
 $V = V_0$
 V_1
 V_2
 $Z_{eq} = R + \frac{1}{j\omega C}$
 $Z_{eq} = \frac{j\omega C R + 1}{j\omega C} = \frac{1 + j\omega RC}{j\omega C}$
 $V = Z_{eq} I \Rightarrow I = \frac{V}{Z_{eq}}$
 $i(t) = \text{Re} [I e^{j\omega t}] = \text{Re} \left[\frac{V}{Z_{eq}} e^{j\omega t} \right]$
 $= \text{Re} \left[\frac{V_0}{R + j\omega C} e^{j\omega t} \right] = \text{Re} \left[\frac{j V_0 \omega RC}{R + j\omega RC} e^{j\omega t} \right]$
 $= \frac{V_0}{R} \frac{\omega RC}{\sqrt{1 + (\omega RC)^2}} \cos(\omega t + \tan^{-1} \frac{1}{\omega RC})$
 CASE 1: $\omega \rightarrow 0$ CASE 2: $\omega \rightarrow \infty$ $L = RC$ $\cos \omega t + j \sin \omega t$

$$i(t) = \text{Re} \left[\frac{1}{R} \frac{V_0 j\omega (R)}{1 + j\omega RC} e^{j\omega t} \right] = \frac{V_0}{R} \text{Re} \left[\frac{j\omega L}{1 + j\omega L} e^{j\omega t} \right]$$

want

$$\frac{j\omega L}{1 + j\omega L} \text{ as } r e^{j\phi}$$

$$\frac{1 - j\omega L}{(1 + j\omega L)(1 - j\omega L)} = \frac{1 - j\omega L}{1 + (\omega L)^2}$$

$$\frac{j\omega L}{1 + j\omega L} = \frac{j\omega L (1 - j\omega L)}{1 + (\omega L)^2} = \frac{j\omega L - (\omega L)^2}{1 + (\omega L)^2}$$

$$= \omega L \frac{\omega L + j}{1 + (\omega L)^2}$$

$$i(t) = \frac{V_0}{R} \text{Re} \left[\omega L \frac{\omega L + j}{1 + (\omega L)^2} e^{j\omega t} \right]$$

$$= \frac{V_0}{R} \frac{\omega L}{1 + (\omega L)^2} \text{Re} \left[(\omega L + j) e^{j\omega t} \right]$$

$$= \frac{V_0}{R} \frac{\omega L}{1 + (\omega L)^2} \text{Re} \left[\sqrt{(\omega L)^2 + 1} e^{j\phi} e^{j\omega t} \right]$$

$$\omega\tau + j = |\omega\tau + j| e^{j\phi} = \sqrt{(\omega\tau)^2 + 1} e^{j\phi}$$

$$\phi \equiv \tan^{-1} \frac{\text{Im}(\omega\tau + j)}{\text{Re}(\omega\tau + j)} \equiv \tan^{-1}\left(\frac{j}{\omega\tau}\right)$$

$$|\omega\tau + j| = \sqrt{(\omega\tau)^2 + 1}$$

$$i(t) = \frac{V_0}{R} \frac{\omega\tau}{\sqrt{1 + (\omega\tau)^2}} \text{Re} \left[e^{j\phi} e^{j\omega t} \right]$$

$$= \frac{V_0}{R} \frac{\omega\tau}{\sqrt{1 + (\omega\tau)^2}} \cos(\omega t + \phi)$$

$$\phi \equiv \tan^{-1}\left(\frac{j}{\omega\tau}\right)$$

Find $i(t)$, $V_1(t)$, $V_2(t)$ for this circuit: (instructor)

I \downarrow \checkmark \checkmark
 consider cap only: $\frac{1}{j\omega C}$ $\downarrow i(t) \rightarrow I \rightarrow V = Z I \rightarrow V_1(t)$

From above $I = \frac{V_0}{R} \frac{j\omega L}{1 + j\omega L}$

$V = \frac{1}{j\omega C} I = \frac{V_0}{R} \frac{j\omega L}{1 + j\omega L} \frac{1}{j\omega C}$

$V_1(t) = \text{Re} [V e^{j\omega t}] = \text{Re} \left[\frac{V_0}{R} \frac{j\omega L}{1 + j\omega L} \frac{1}{j\omega C} e^{j\omega t} \right]$

After work:

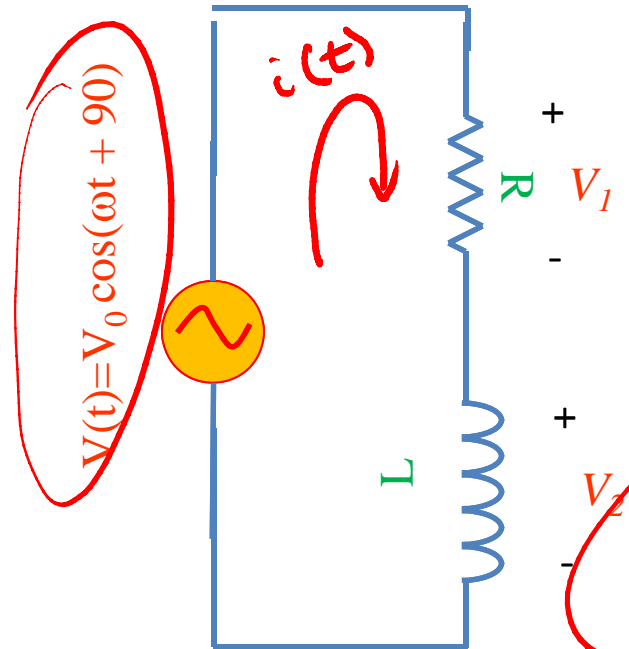
$V_{1(t)} = \frac{V_0}{\sqrt{1 + (\omega L)^2}} \left(\cos \omega t + [-\tan^{-1}(\omega L)] \right)$
 LPF

$V_2(t)$ \downarrow $i(t) \rightarrow I \rightarrow V = Z I \rightarrow V_2(t)$
 R exc.

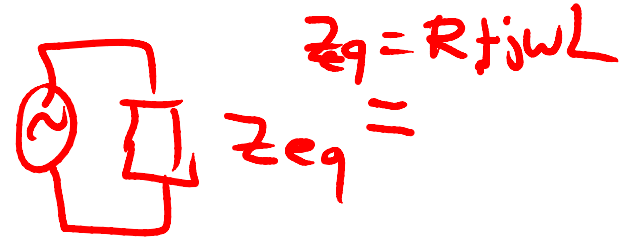
$V_{2(t)} = \frac{V_0 \omega L}{\sqrt{1 + (\omega L)^2}} \cos \left(\omega t + \tan^{-1} \frac{1}{\omega L} \right)$
 HPF

Example problem #4

Find $i(t)$, $V_1(t)$, $V_2(t)$ for this circuit: (students)



1) Draw as



2) $V(t) \rightarrow$

$$V = V_0 \angle 90^\circ = V_0 e^{j90^\circ} = V_0 e^{j\frac{\pi}{2}}$$

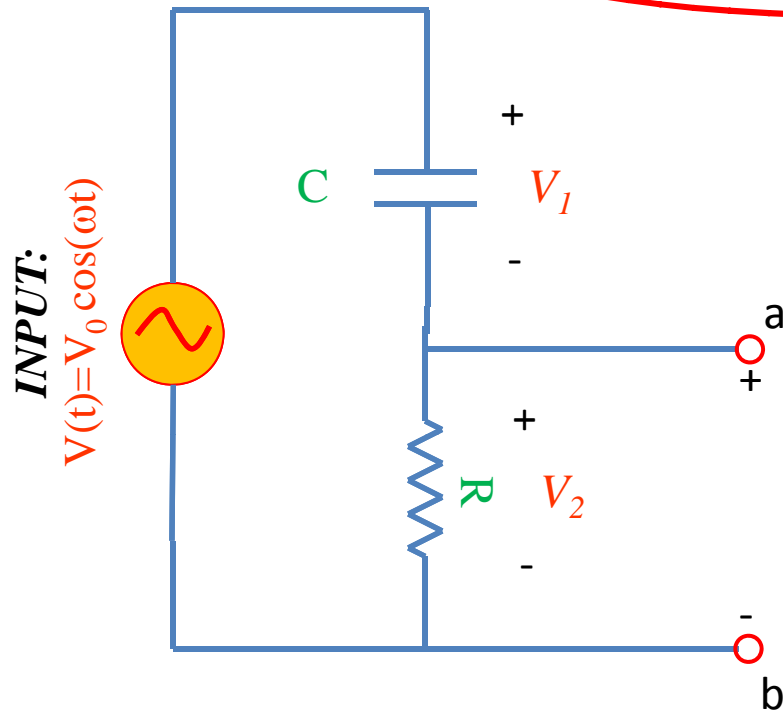
3) $I = \frac{V}{Z_{eq}}$

4) $i(t) = \text{Re}[I e^{j\omega t}]$

$$I = \frac{V_0 e^{j\pi/2}}{R + j\omega L}$$

$$i(t) = \text{Re}\left[\frac{V_0 e^{j\pi/2}}{R + j\omega L} e^{j\omega t} \right]$$

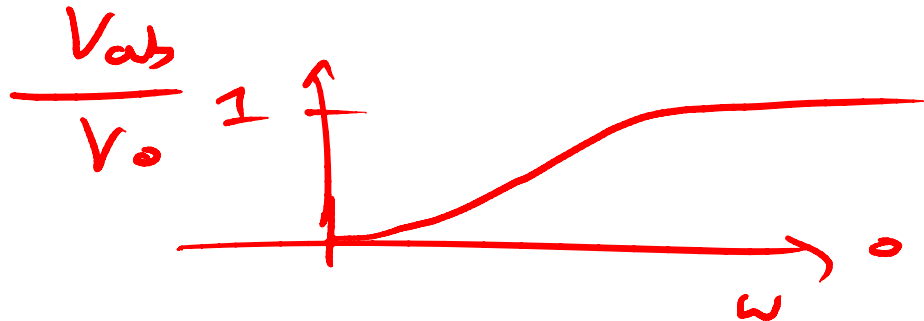
High pass filter



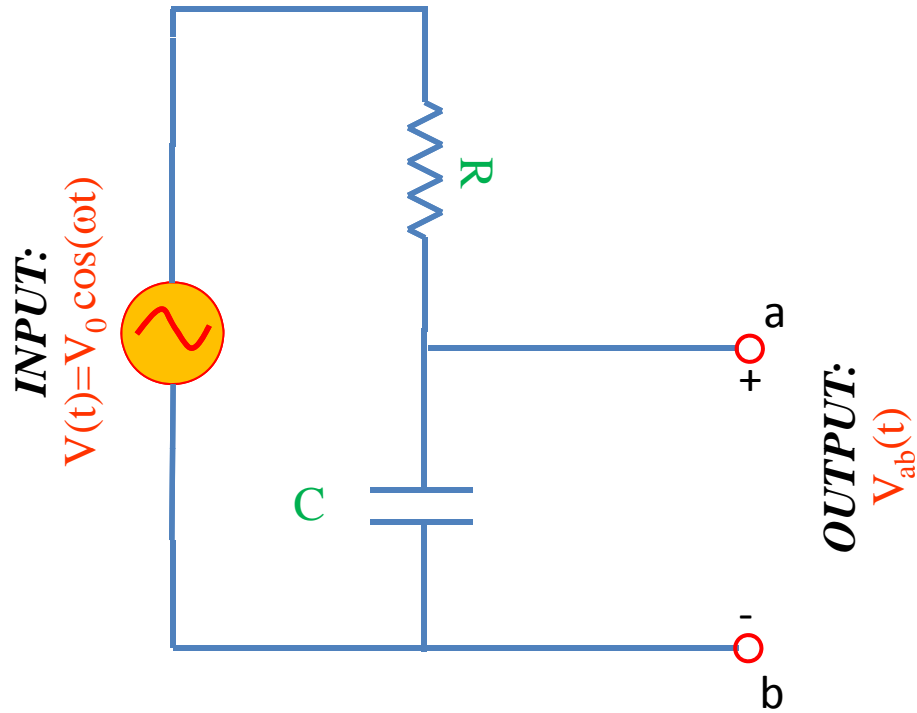
$$V_{ab}(t) = R i(t)$$

$$= R \frac{V_0}{R} \frac{\omega \tau}{\sqrt{1 + (\omega \tau)^2}} \cos(\omega t + \phi)$$

$$\frac{V_{ab}}{V_0} = \frac{\omega \tau}{\sqrt{1 + (\omega \tau)^2}} \cos(\omega t + \phi)$$



Low pass filter



“Transfer function”

$$V_{in}(t) = V_m \cos(\omega t)$$

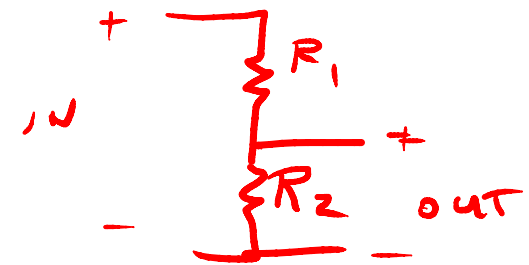
$$V_{in} = V_m$$

$$H(\omega) \equiv \frac{Y}{X}$$

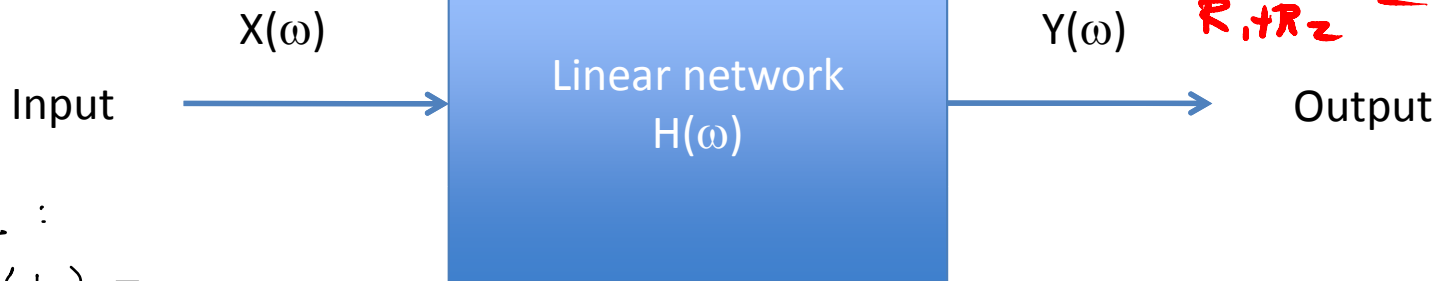
$$V_{out} = H(\omega) V_{in} = H(\omega) V_m$$

$$v(t) = \text{Re} [H(\omega) v_{in} e^{j\omega t}]$$

$$\text{if } H(\omega) \text{ real} \Rightarrow v_{out}(t) = H(\omega) v_{in} \cos(\omega t)$$



$$\frac{R_2}{R_1 + R_2} = \frac{V_{out}(t)}{V_{in}(t)}$$



EX :

$$V_{out}(t) =$$

$$|H(\omega)| v_{in} \cos(\omega t + \phi)$$

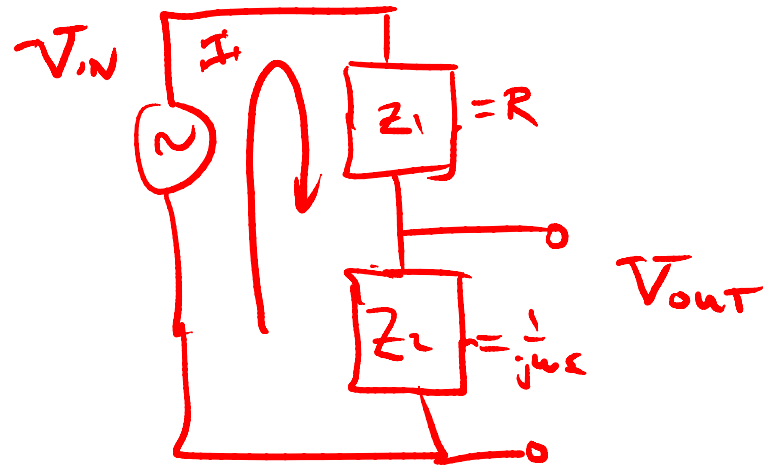
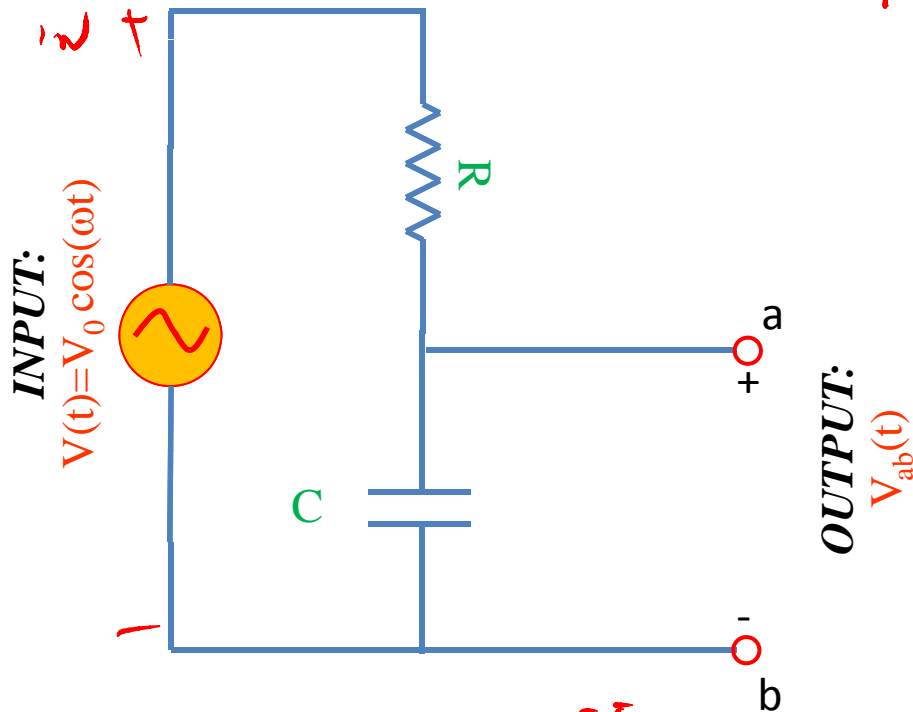
$$\phi \equiv \tan^{-1} \frac{\text{Im } H(\omega)}{\text{Re } H(\omega)}$$

demo

$$\Rightarrow H(\omega) = \frac{V_{output}}{V_{input}}$$

RC transfer function

FIND $H(\omega)$



$$I = \frac{V_{IN}}{Z_1 + Z_2}$$

$$V_{OUT} = I Z_2 = \frac{V_{IN}}{Z_1 + Z_2} Z_2$$

$$\Rightarrow \frac{V_{OUT}}{V_{IN}} = \frac{Z_2}{Z_1 + Z_2} = \frac{1}{1 + j\omega RC} = \underline{\underline{H(\omega)}}$$

Band pass filter (RLC)

