Hydraulic

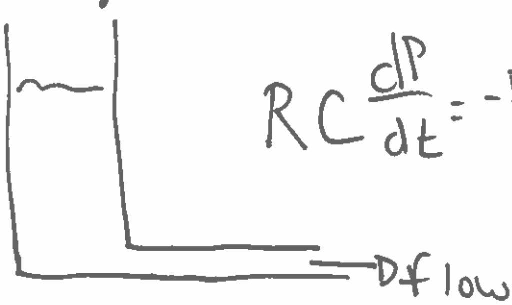
$\Delta P = \text{flow} \cdot R$

$\text{Volume} = \int \text{flow}$

$\text{Capacitance} \equiv \frac{\text{Volume}}{\text{Pressure}}$

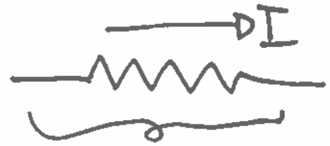
$\text{flow} = C \frac{dP}{dt}$

Draining

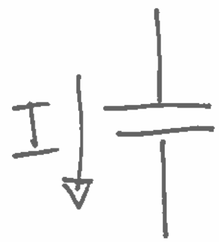


$RC \frac{dP}{dt} = -P$

Electrical



$\Delta V = IR$



$\text{Charge} = \int I \, dt$

$I = C \frac{d\Delta V}{dt}$

Draining

$RC \frac{dV}{dt} = -V$

General

$\text{Effort} = \text{flow} \times R$

"Resistor"

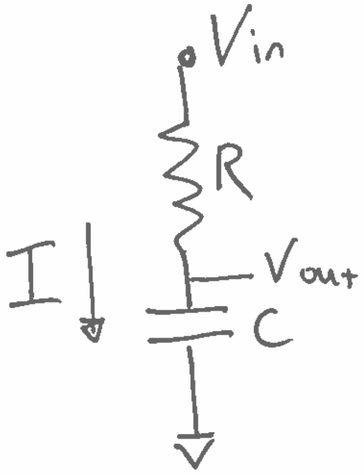
$\text{Effort} = \frac{1}{C} \int \text{flow}$

$\text{flow} = C \frac{d\text{Effort}}{dt}$

"Storage, or Cap."

Draining through resistor

$RC \frac{d\text{Effort}}{dt} = -\text{Effort}.$



$$I_R = \frac{V_{in} - V_{out}}{R}$$

$$I_C = C\frac{dV_{out}}{dt}$$

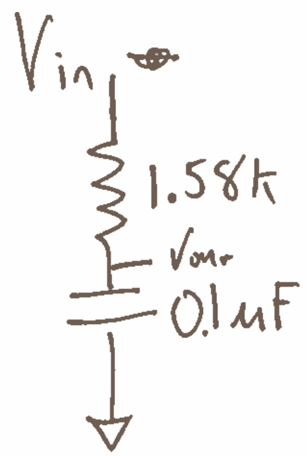
$$I_C = I_R \implies RC\frac{dV_{out}}{dt} = V_{in} - V_{out}$$

If V_{in} Constant

$$V_{out} = \left(V_{out}(0) - V_{in}\right)e^{-t/RC} + V_{in}$$

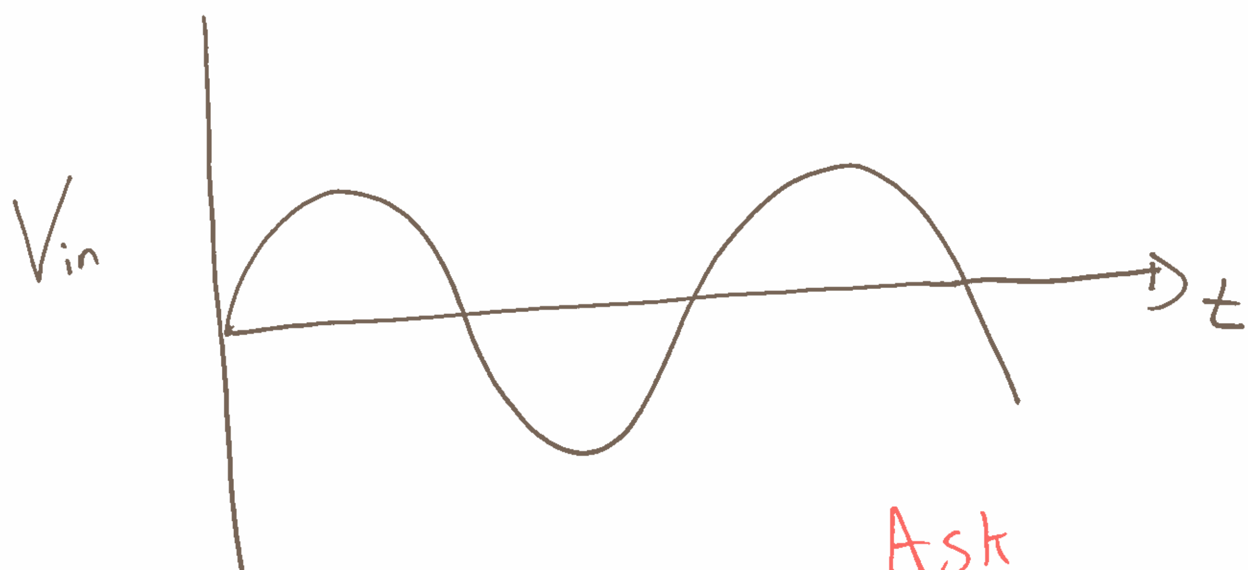
Important piece.

RC sets the time it takes for exponential to decay.



Demo. Square wave just like last week's lab. Low + high frequency behaviors are seen.

For Sin(ωt), Sketch $V_{out}(t)$



Sketch for 100 Hz

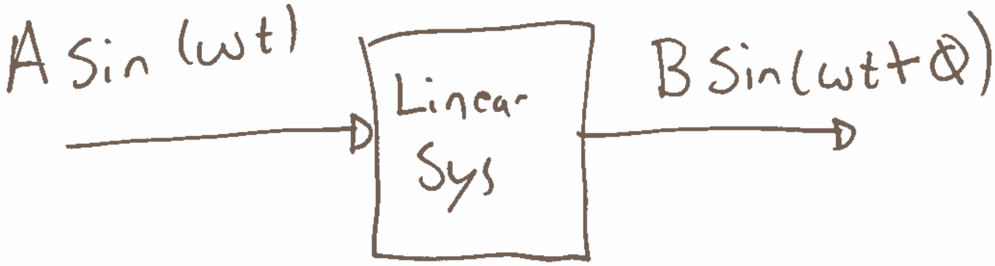
1 000 Hz

10,000 Hz

Ask

- How does freq of V_{out} change as I vary ω
- How does Amp of V_{out} vary?

Linear Systems



Bode plot $\frac{B(\omega)}{A}$, $\Phi(\omega)$

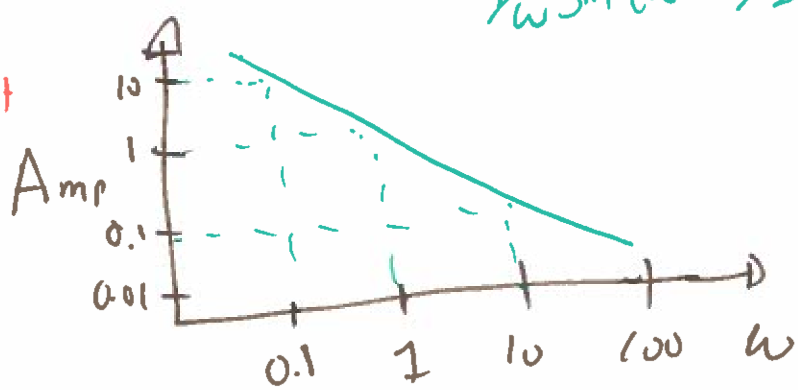
Example

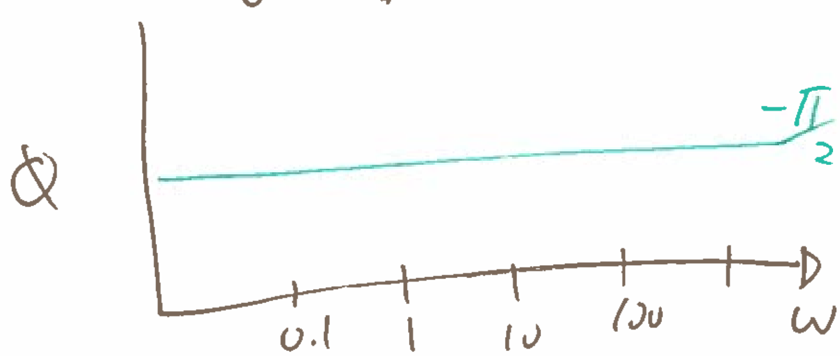
What Signal Comes out?

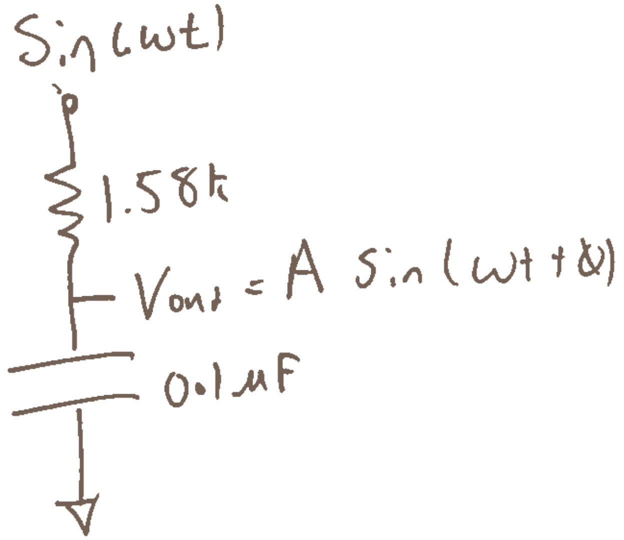
$-\frac{1}{\omega}\cos(\omega t) = -\frac{1}{\omega}\sin(\omega t + \pi/2) =$

$1/\omega \sin(\omega t - \pi/2)$

Sketch Bode plot







$$\phi = \operatorname{atan}(-RC\omega)$$

$$A = \frac{1}{\sqrt{1+(RC\omega)^2}}$$

Fill out table

	RCω	A	φ
ω = 100 Hz	0.1	$1/\sqrt{1.1}$	
500	0.5	$1/\sqrt{1.5}$	
1,000	1	$1/\sqrt{2}$	
3,000	3	$1/2$	
10,000	10	$1/\sqrt{11}$	

Demo

test each point

Auto Bode plot generator.