Hilroy

80 Pages
27.6 cm x 21.2 cm

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EXERCISE BOOK
CAHIER D'EXERCICES

NAME/NOM Cole Shanks

SUBJECT/SUJET ELEC 202

ASSEMBLED IN CANADA WITH IMPORTED MATERIALS
ASSEMBLÉ AU CANADA AVEC DES MATIÈRES IMPORTÉES

12107

ELEC 202 LEC 1

1/02/19
LEC

Ohm's Law $GV = I$ where $G = \frac{1}{R}$ (conductance) * in Siemens

Complex numbers

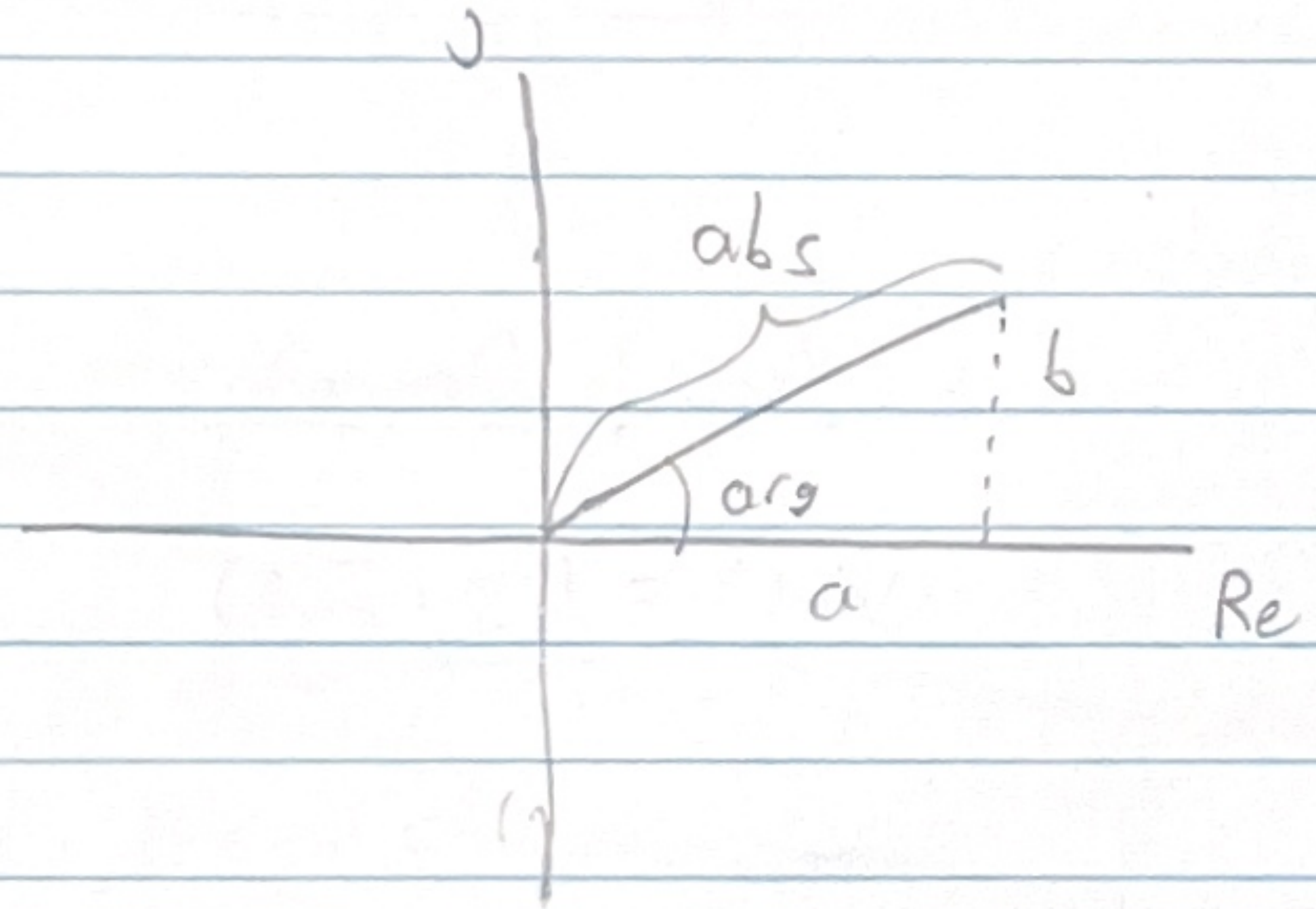
$(3 + j4)(5 - j7) = 43 - j$

Rectangular form :

$(3, 4)(5, -7) = (43, -1)$

Polar Form :

abs $\angle$ arg°



$v(t) = 30\cos(377t + 25°)$

$\omega = 2\pi f$

$\bar{V} = 30 \angle 25°$

Laplace Domain

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Laplace

$f(t) \longleftrightarrow F(s)$

$u(t) \longleftrightarrow \frac{1}{s}$

$e^{-at} u(t) \longleftrightarrow \frac{1}{s+a}$

$t\,u(t) \longleftrightarrow \frac{1}{s^2}$

$\delta(t) \longleftrightarrow 1$

For the inductor

Time Domain	Laplace Domain
$V(t) = L\frac{di}{dt}$	$V(s) = \underbrace{Ls}\cdot I(s)$

Impedance (Z) of the inductor in Ohms

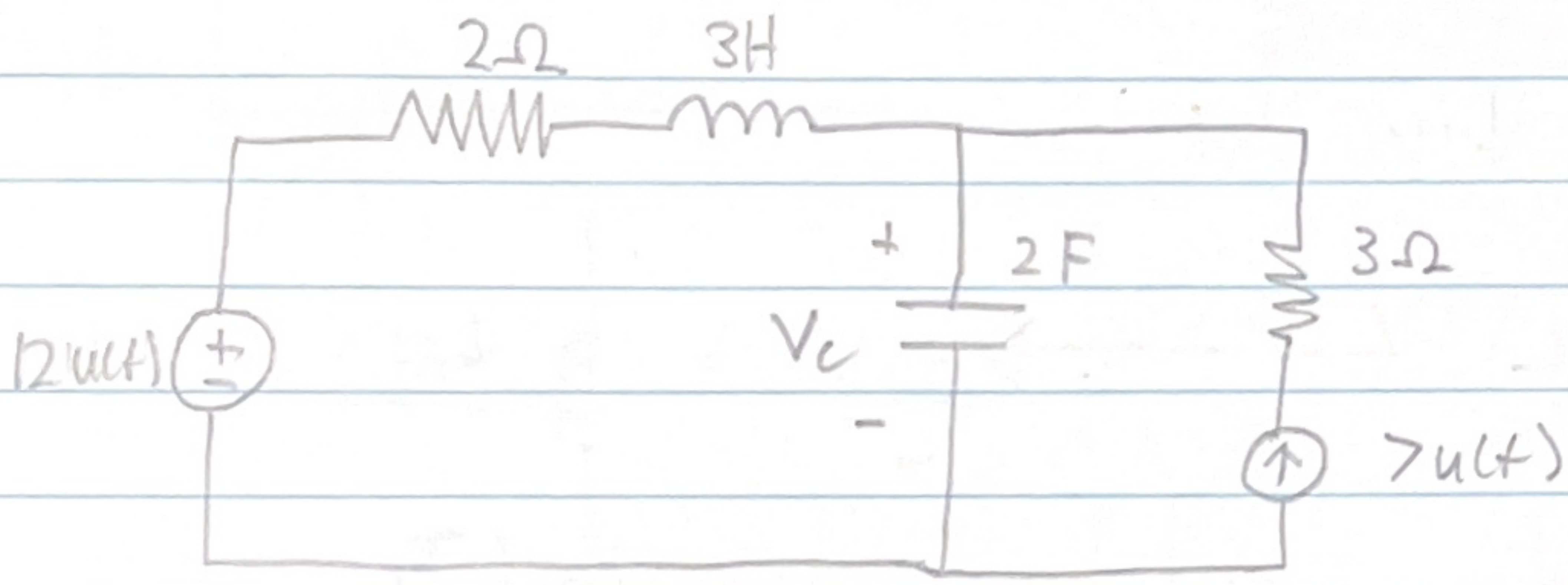
For the Capacitor

Time Domain	Laplace Domain
$I(t) = C\frac{dV}{dt}$	$I(s) = Cs \cdot V(s)$
	$V(s) = \underbrace{\frac{1}{Cs}} \cdot I(s)$

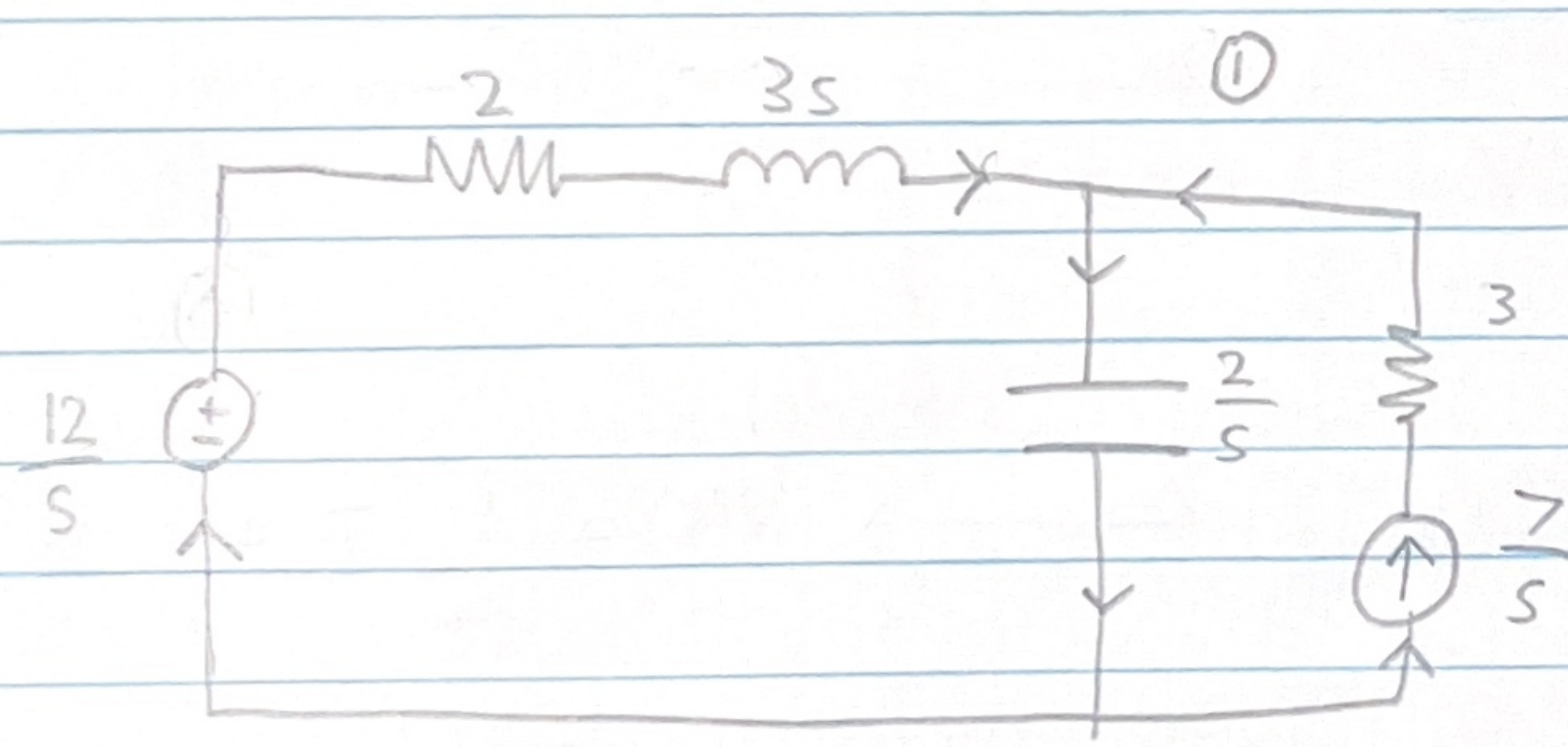
Impedance (Z) of the Capacitor in Ohms

$\boxed{\text{MNA in Laplace Domain}}$

$I(s) = V_3 - V_7$



Laplace Domain



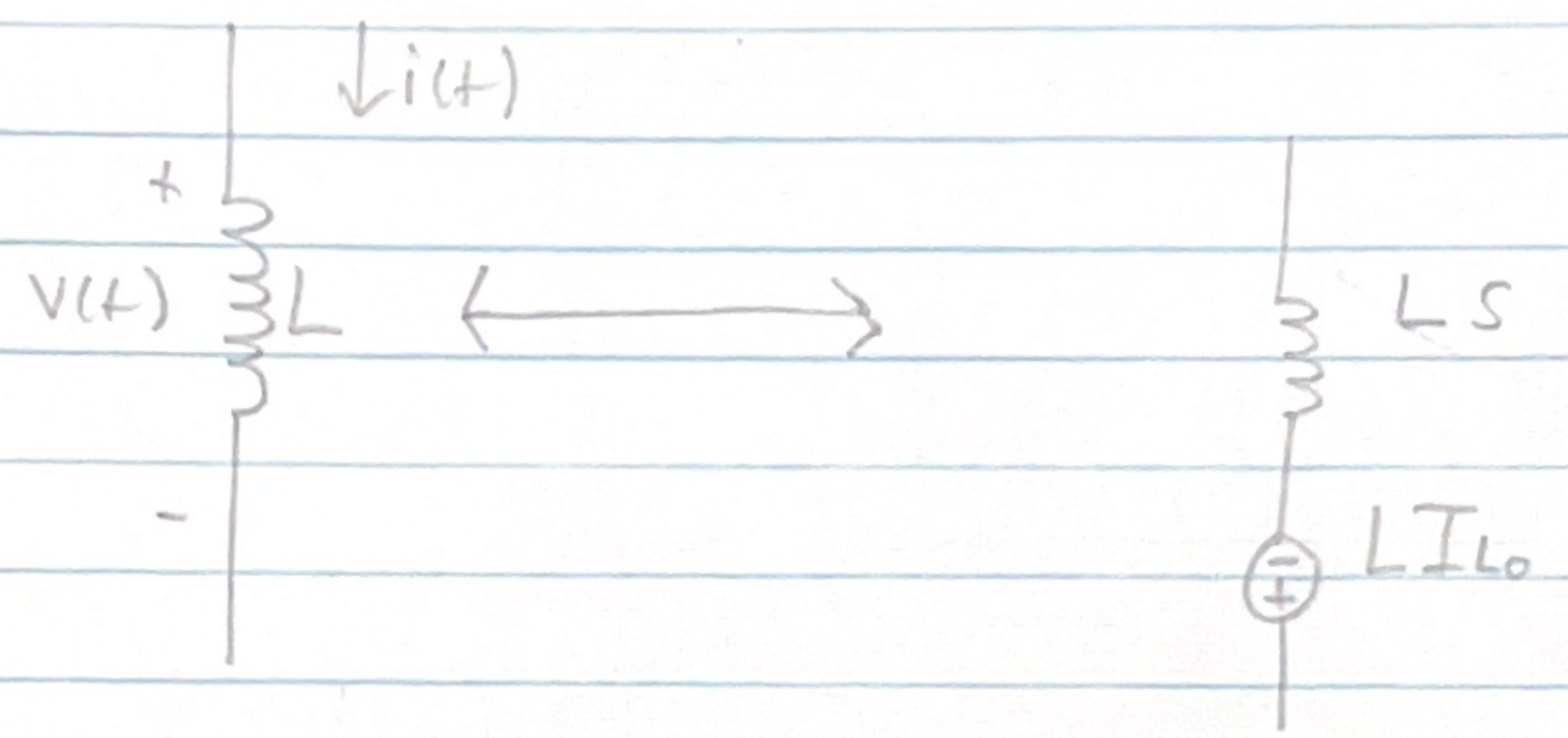
$$KCL_1 : \frac{7}{s} + \frac{\frac{12}{s} - V_1}{2+3s} = \frac{V_1 \cdot s}{2}$$

$$V_1 = \frac{42s + 52}{3s^3 + 2s^2 + 2s}$$

Accounting For IC

Inductors:

$$v(t) = L\frac{di}{dt} \longleftrightarrow V(s) = Ls\,I(s) - L I_{L0}$$



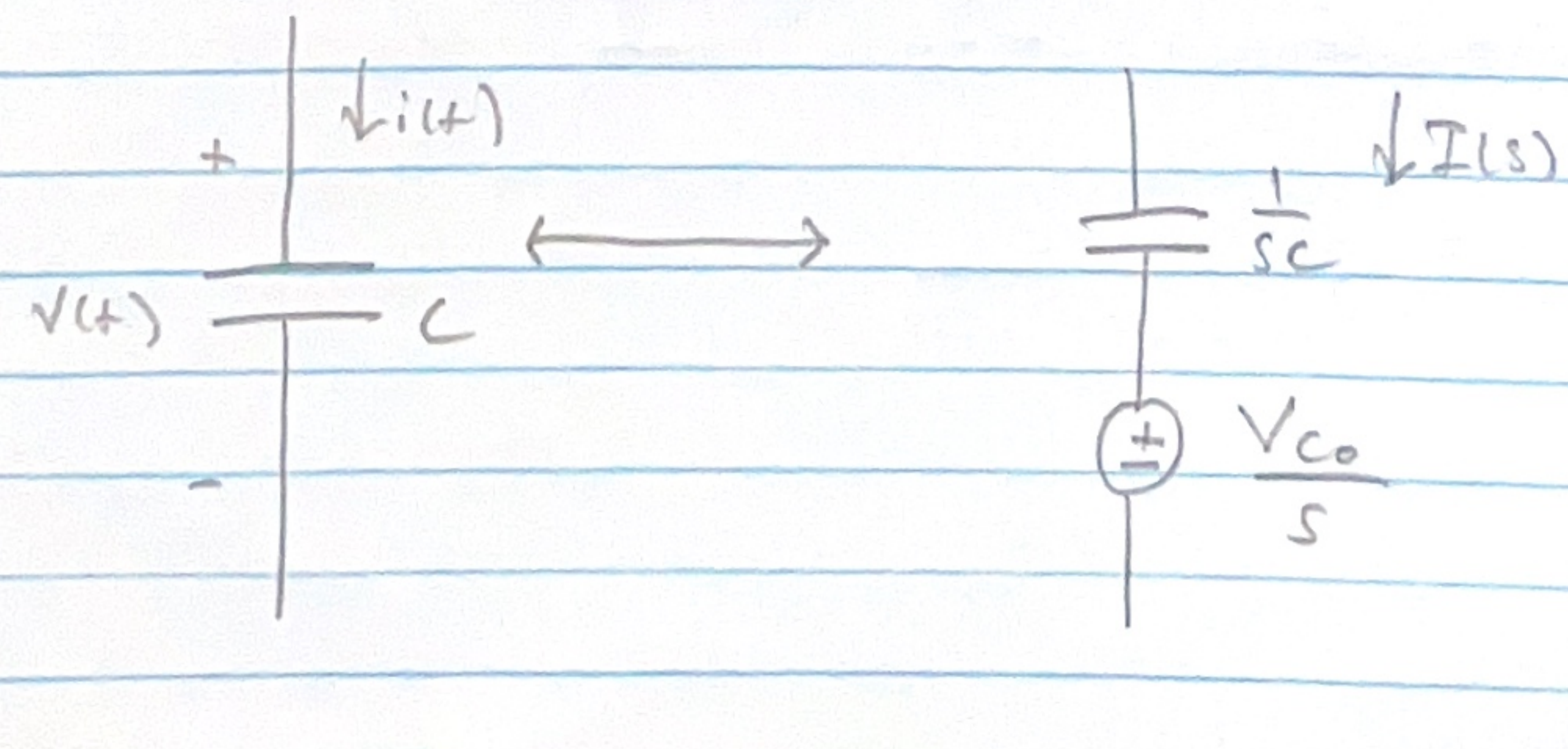
Capacitors:

$$i(t) = C\frac{dV}{dt}$$

initial voltage

$$v(t) = \frac{1}{C}\int i(t)\,dt \longleftrightarrow V(s) = \frac{1}{sC} I + \frac{1}{C}\frac{q_0}{s}$$

$$V(s) = \frac{1}{sC} I + \frac{V_{C0}}{s}$$



Laplace Transform

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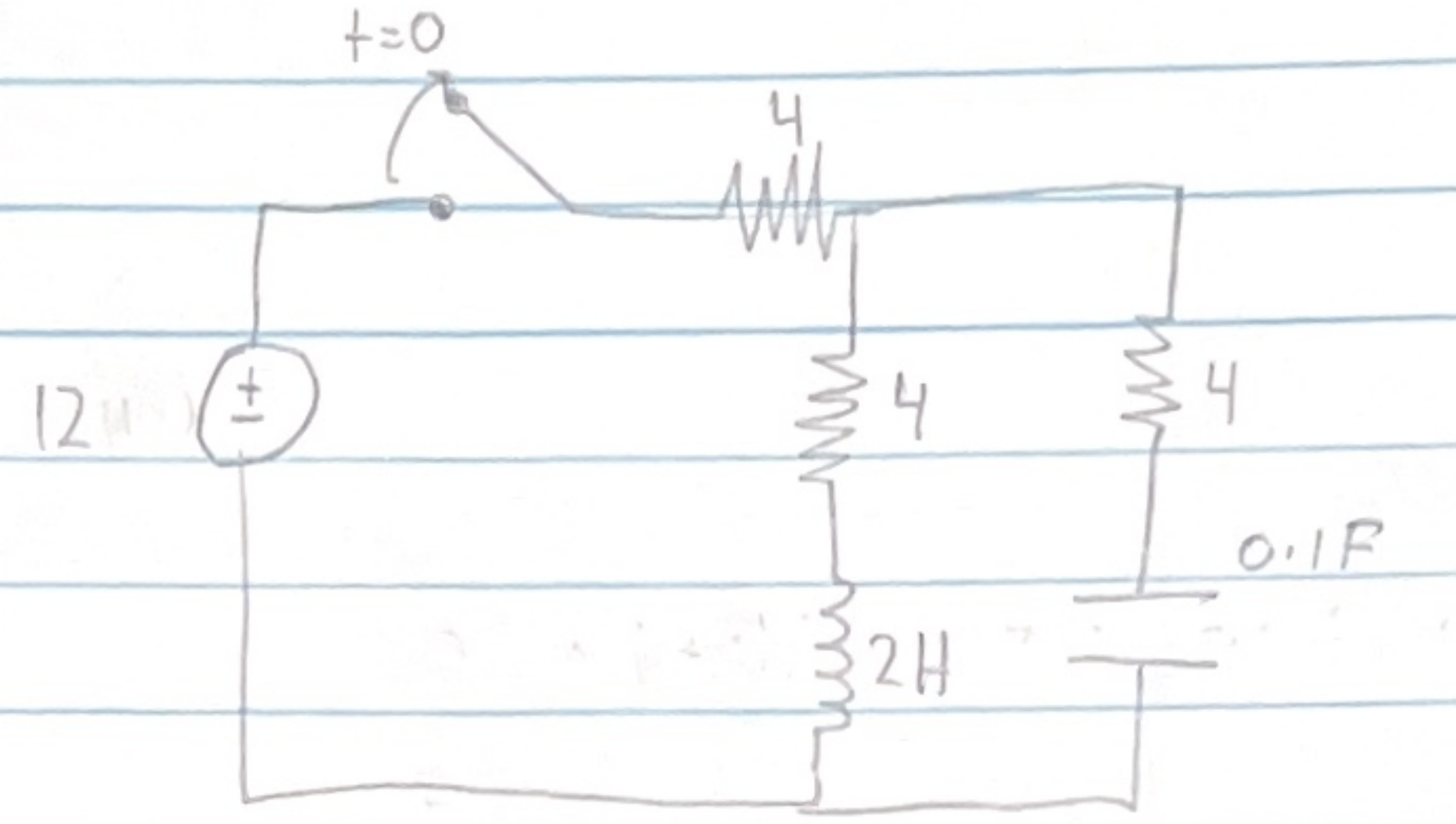


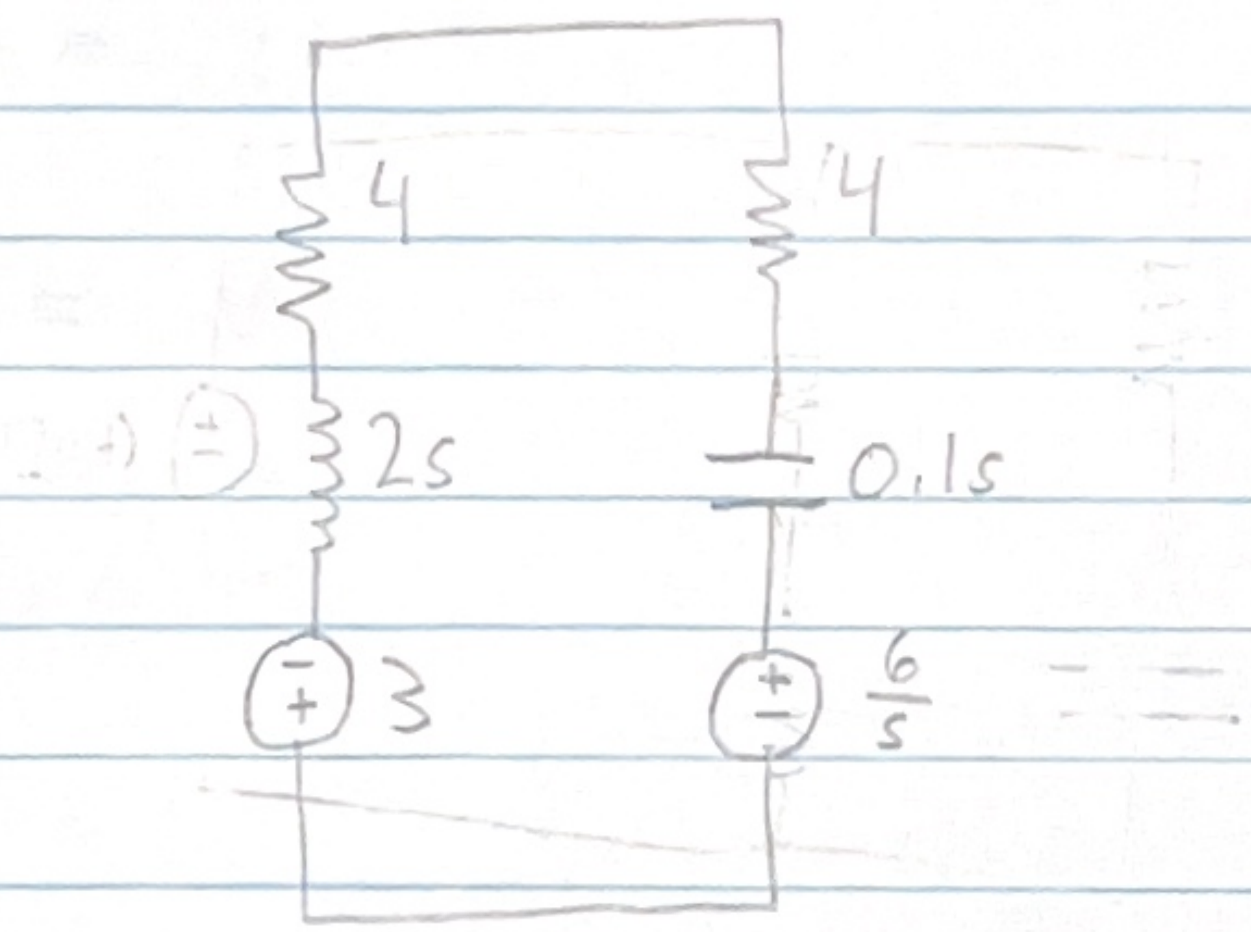
DC.SS Findings:

$I_L = 1.5A$

$V_c = 6V$

t>0

Laplace Domain



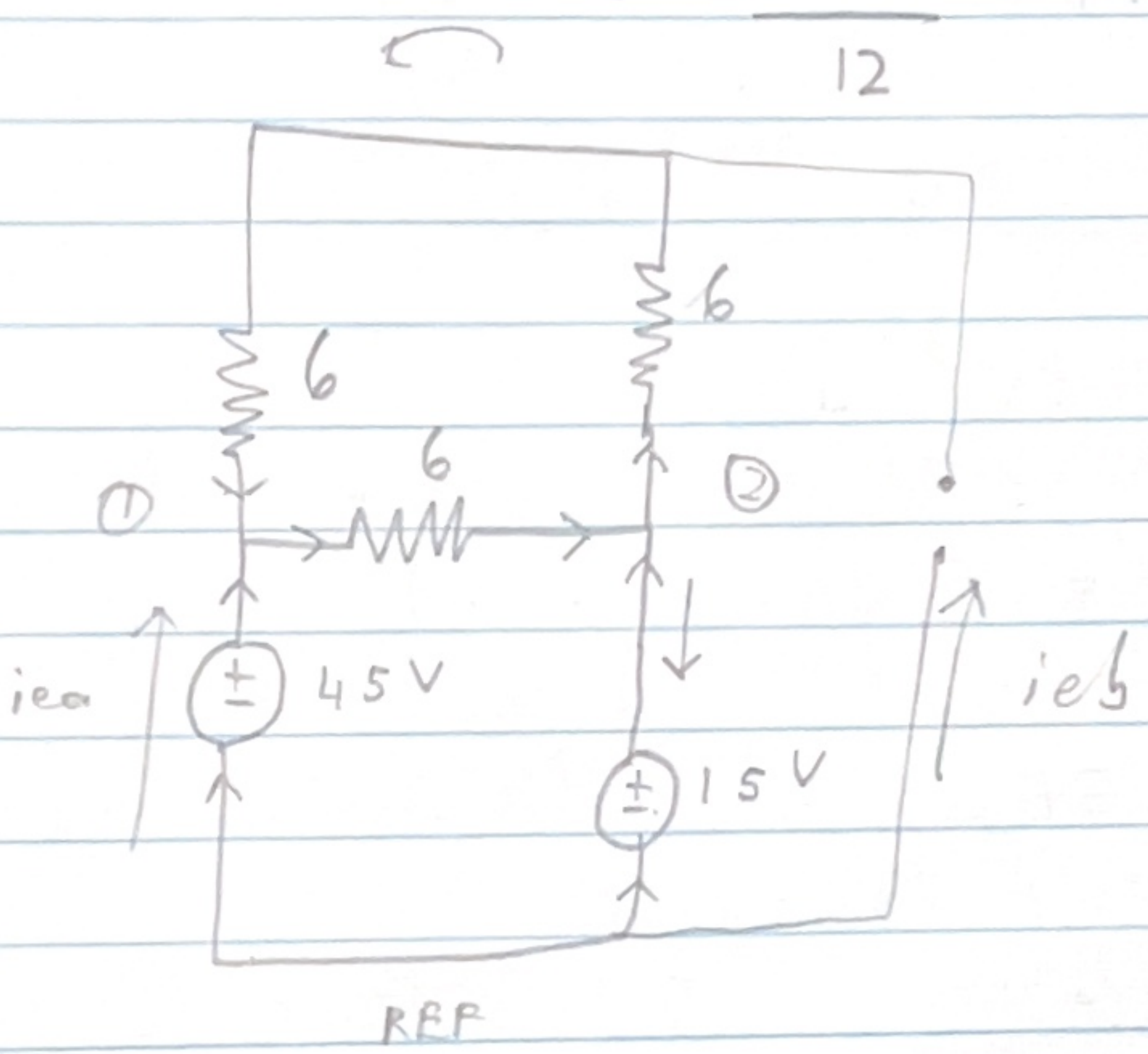
$$I_L = \frac{3 + \frac{6}{s}}{4+4+2s+0.1s} = \frac{3}{2}\cos(t)e^{-2t}$$

Charles Proteus Steinmetz

$\boxed{\text{2nd Order Circuits}}$

# of reactive elements (capacitors / inductors) gives order

$I = \frac{15-45}{12} =$ $V_c = 30V$



$V_1: \; iea + \frac{V_2 - V_1}{12} = \frac{V_1 - V_2}{6}$

$V_2: \; \frac{V_1 - V_2}{6} + ieb = \frac{V_2 - V_1}{12}$

$EVI_1: \; 0 + 45 = V_1$

$EVI_2: \; 0 + 15 = V_2$

$V_2: \; \frac{45-15}{6} + ieb = \frac{15-45}{12}$

$\therefore V_1 =$

$V_2 =$

EVL:

$V_2:$

$V_2: \; \frac{45-15}{6} = \frac{45-15}{12} -$

Frequency Response and Bode Plots

AC steady state

$$v(t) = 9\cos(300t + 45^\circ) \longleftrightarrow \bar{V} = \frac{9}{\sqrt{2}} \angle 45^\circ$$

$$\begin{aligned} \bar{S} &= P + jQ \\ &= \bar{V} \cdot \bar{I} \\ &= S \angle \theta \end{aligned}$$

Transfer Function

$$X(s) \longrightarrow \boxed{H(s)} \xrightarrow{Y(s)}$$

$$Y(s) = H(s)\,X(s)$$

* kill internal sources, kill I'Cs → Find $\frac{Y(s)}{X(s)} = H(s)$

Decibels from Transfer Function (α_{DB})

$$\alpha_{DB} = 20\log_{10} |H(s)| \Big|_{s=j\omega}$$

zeroes

$$H(s) = \frac{a_n s\,(s+z_1)(s+z_2)\ldots(s+z_n)}{(s+p_1)(s+p_2)\ldots(s+p_n)}$$

poles

Stability of Poles

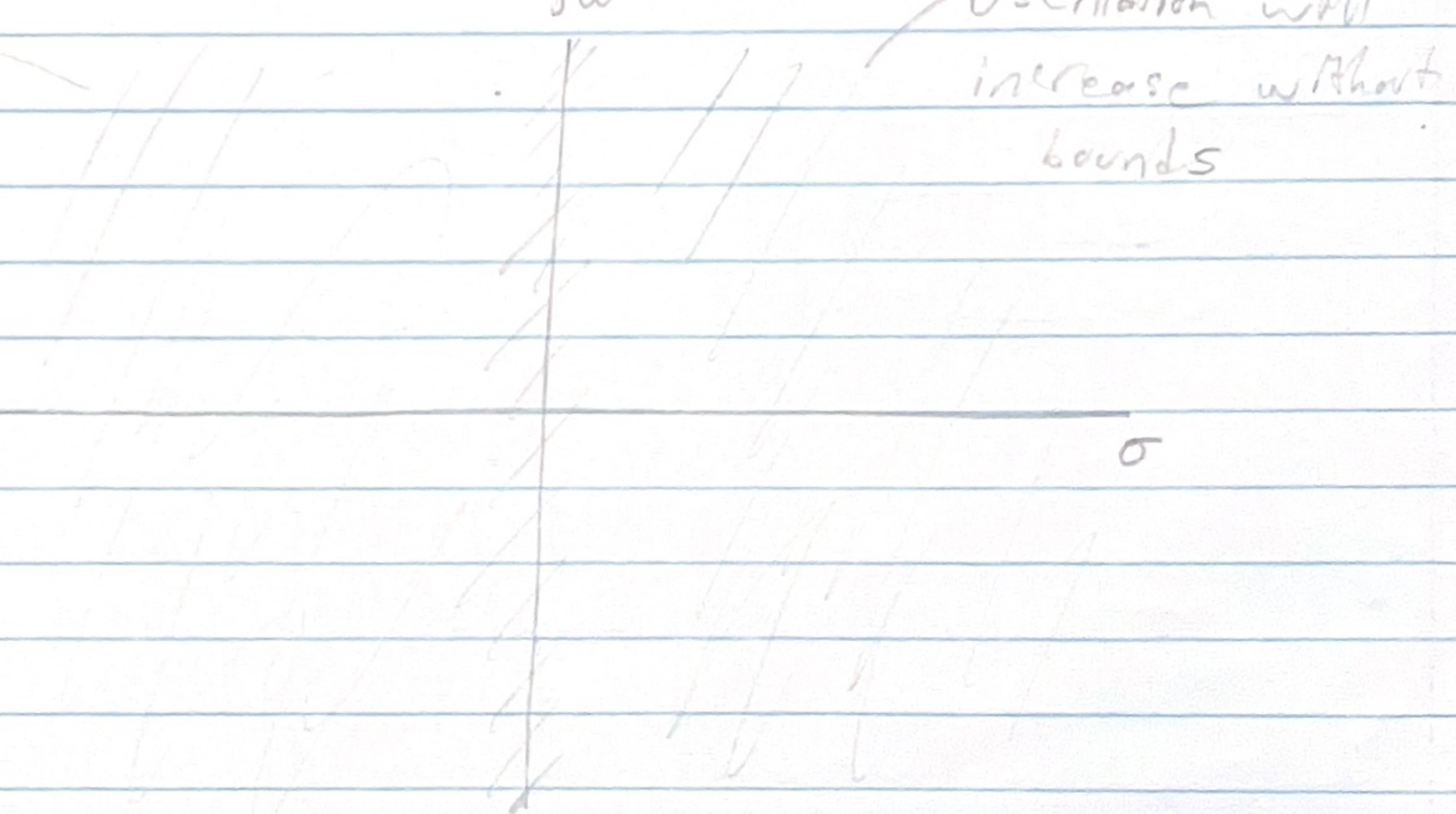
$h(t) = k_1 e^{\sigma_1 t} e^{j\omega_1 t} \ldots\ldots k_n e^{\sigma_n t} e^{j\omega_n t}$

To be stable all $\sigma_n = 0$

* That means all Poles (complex numbers) are on the ~~[illegible]~~ j axis in complex plane

The oscillation will eventually die off

Oscillation will increase without bounds



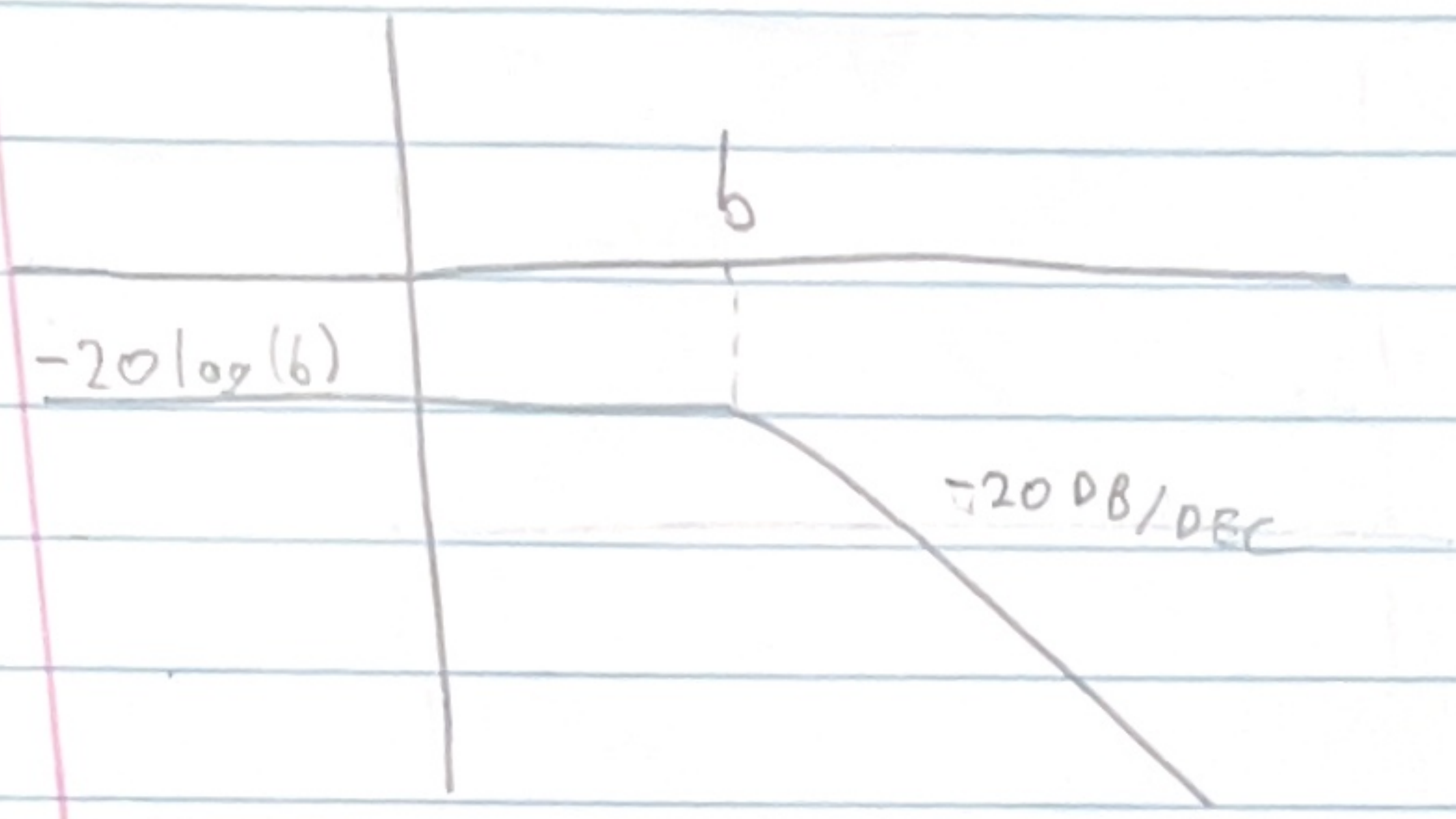
oscillation will never dissapear

$$|H(s)| = \frac{a_n |s||s+z_1| \ldots |s+z_n|}{|s+p_1| \ldots\ldots |s+p_n|}$$

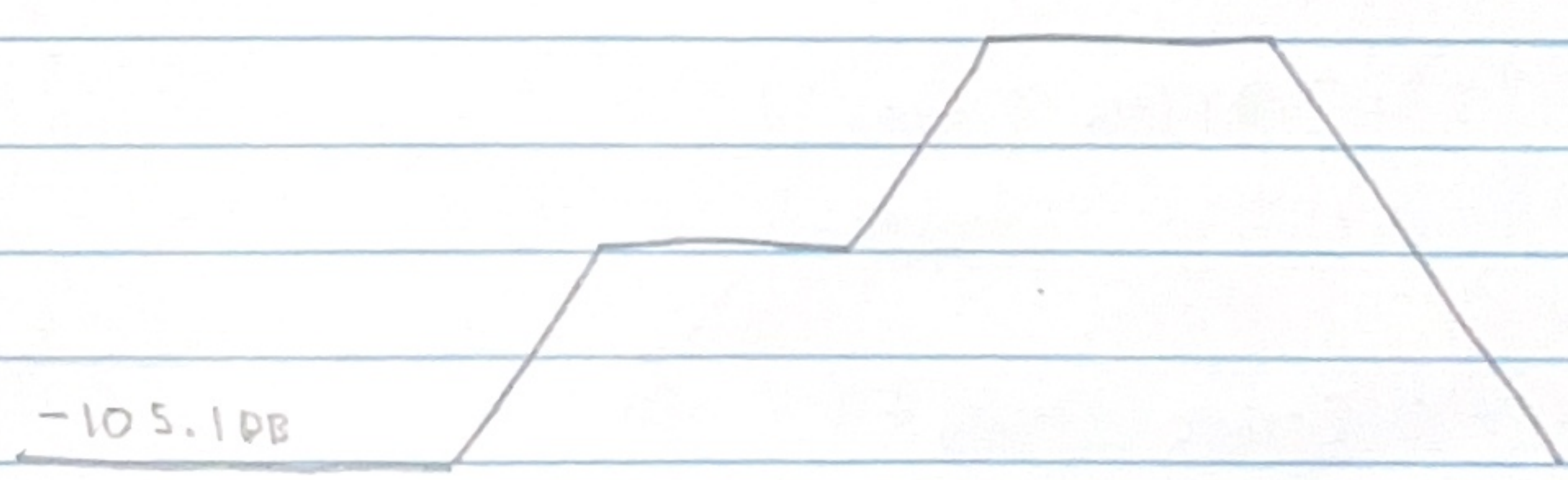
$$H_{DB} = 20\log a_n + 20\log|\omega| + 20\log\sqrt{\omega^2+z_1^2}$$
$$- 20\log\sqrt{\omega^2+p_1^2} \ldots\ldots$$

Bode Plots

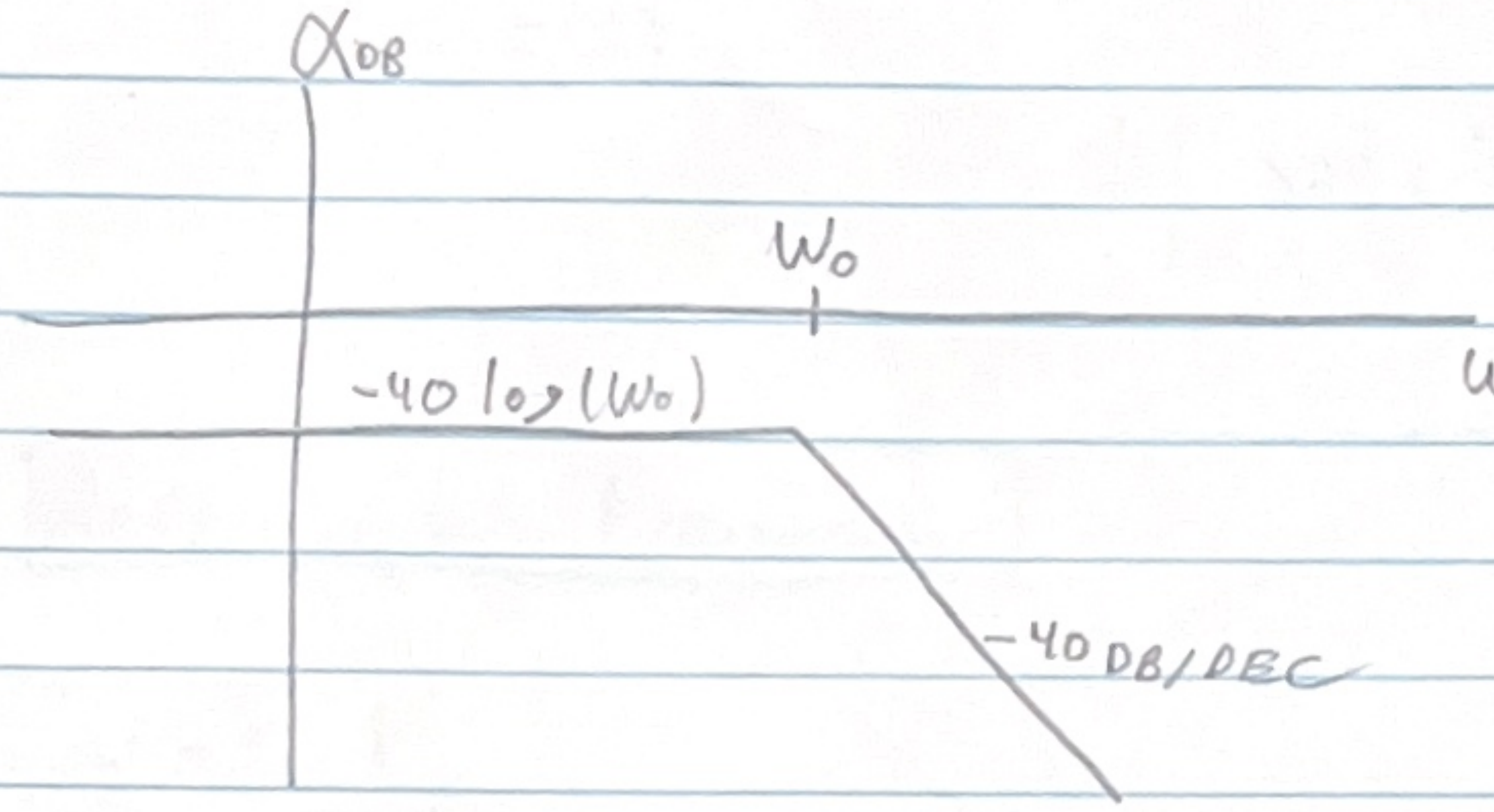
$$H(s) = \frac{1}{(s+6)}$$



$$H(s) = \frac{(s+20)(s+500)}{(s+150)(s+1200)(s+10{,}000)}$$



$$H(s) = \frac{1}{s^2 + 2\xi W_0 s + W_0^2}$$

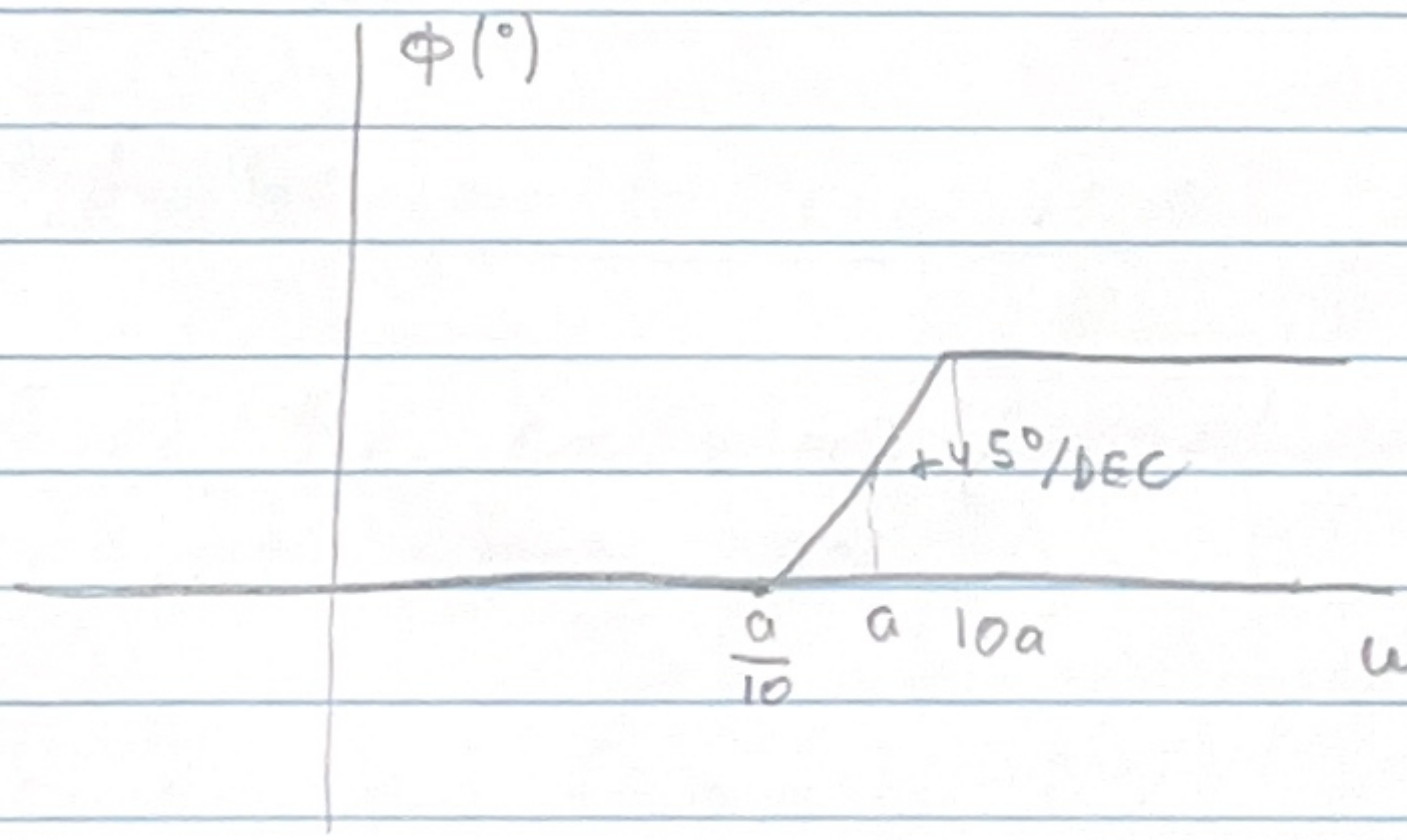


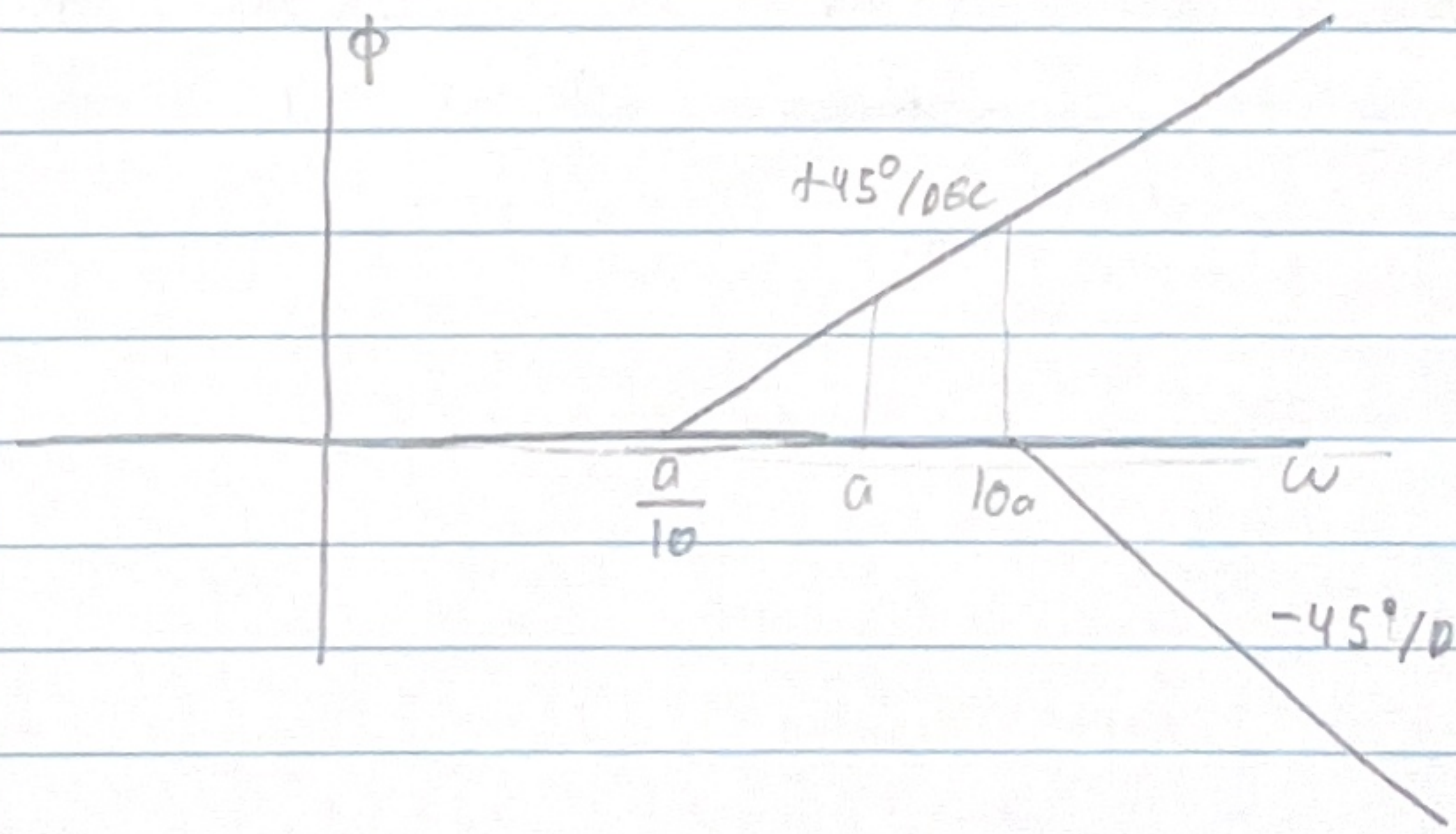
Phase

$H(s) = j\omega$ (shift x-axis up $90°$)

$H(s) = 5s(s+a)$ ⟶ no effect

$H(s) = (s+a)$





Resonance

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$H(s) = \frac{Y(s)}{X(s)}$

$\alpha \big|_{s=jw}$ in DB

$\phi \big|_{s=jw}$ in °

Resonance Frequency

$$W_o = \frac{1}{\sqrt{LC}}$$

Quality Factor

$$Q = \frac{W_o}{BW}$$

* Another way to see it:

Find the equivilant impedance Z of the circuit, where $s = jw$

Find the frequency (W) where the angle of the impedance is zero, ie $Im(X(W)) = 0$ then that W is the resonance frequency

$\boxed{\text{Filters}}$

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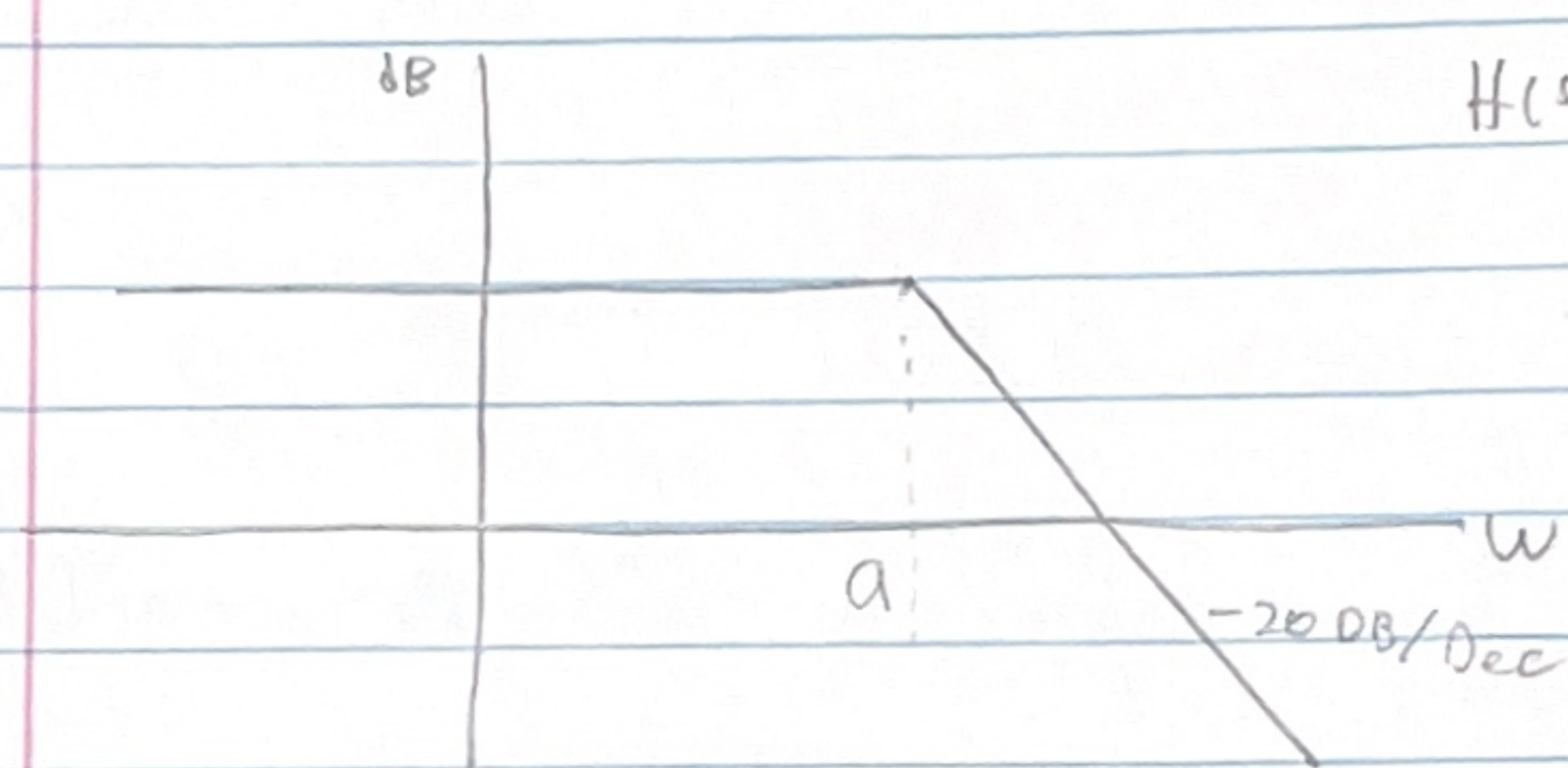
Pass band → W_p = cutoff frequency

$\boxed{\text{Filters}}$ → 4 types

* Edges of the filter are the poles of the function

$$H(s) = \frac{k}{(s+a)}$$

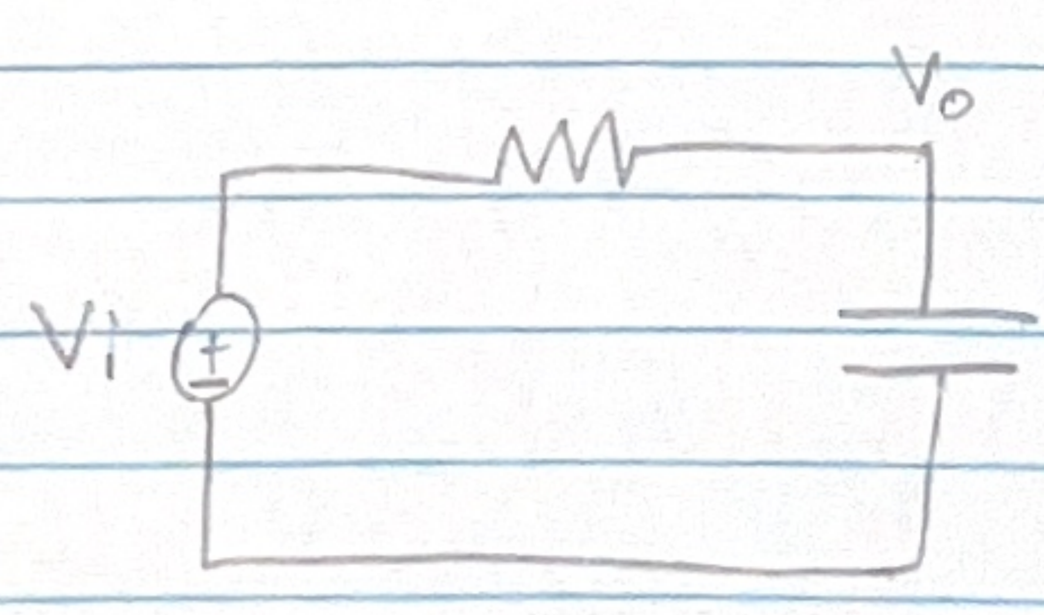


Approximated age = Pole
(cutoff)

$$\frac{2s}{10{,}000} - 1$$

$$H(s) = \frac{25000}{s+6500}$$

$$X_{dB} = \frac{25000}{\sqrt{(10^x)^2 + 6500^2}} \rightarrow \text{Calculator}$$



kcl: $\frac{0 + V_i - V_o}{R} = V_o \cdot C \cdot s$

$$\frac{V_o}{V_i} =$$

Filters

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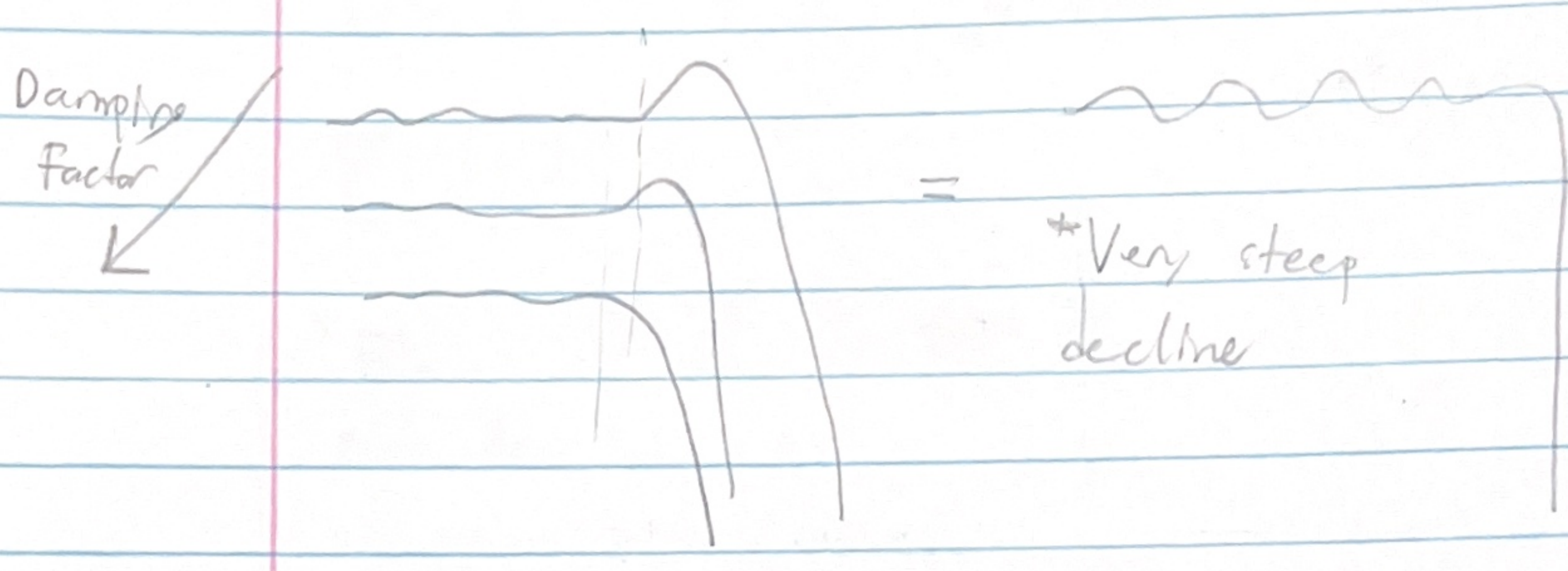
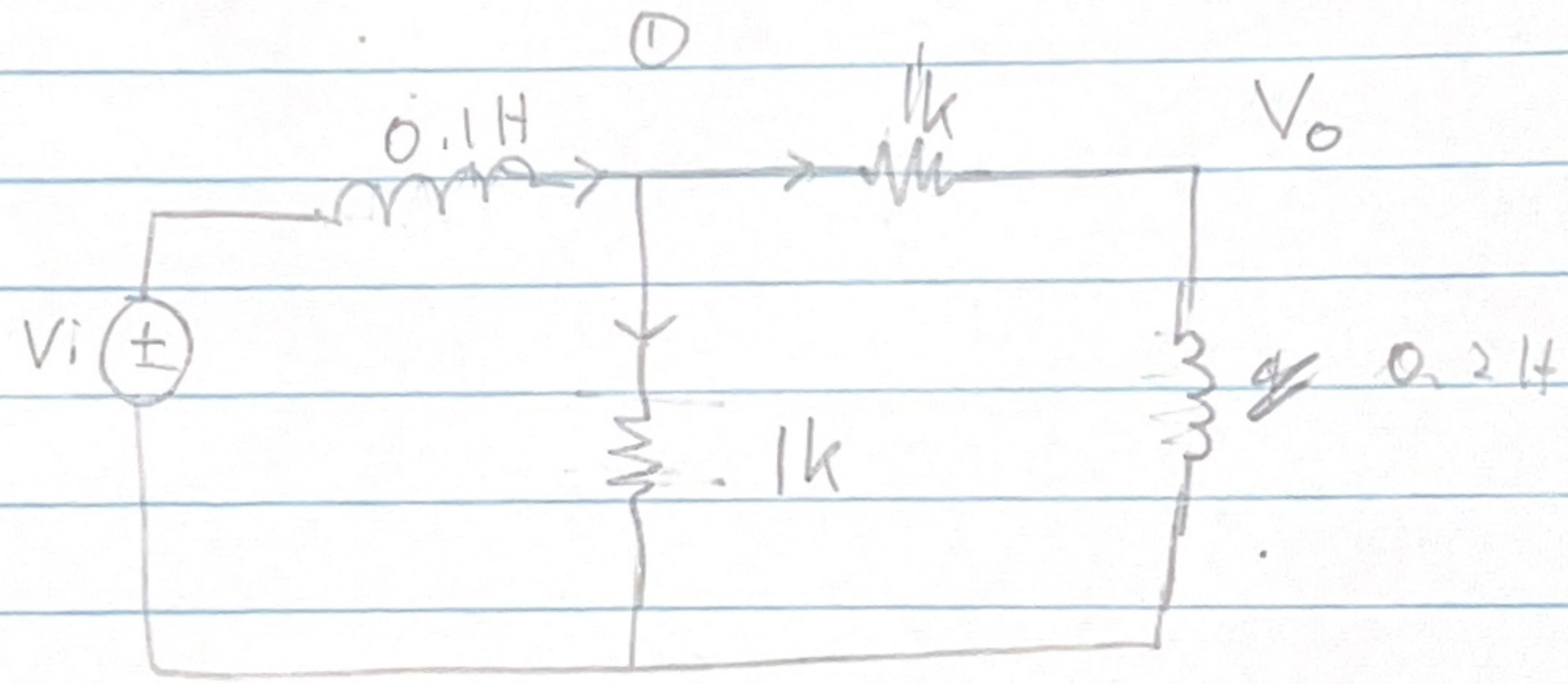
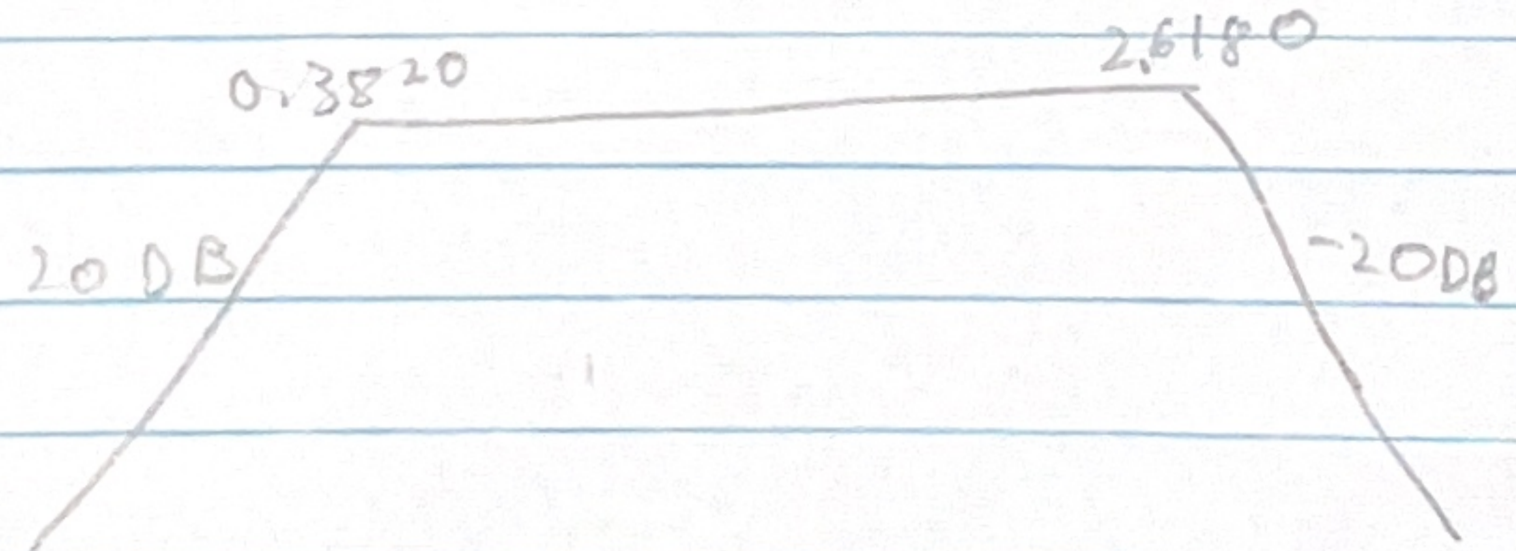
$\boxed{\text{Butterworth Filters}}$ (Chebyshev**)





$$H(s) = \frac{s}{s^2+3s+1}$$



$W_0 = 1$

~~Q 20~~

$$KCl_1: \frac{V_i - V_1}{0.1s} = \frac{V_1}{1k} + \frac{V_1 - V_0}{1K}$$

$BW = W_2 - W_1$

$$EQ_2: \frac{V_1 - V_0}{1k} = \frac{V_0 - 0}{s \cdot 0.2}$$

Two-Port Networks

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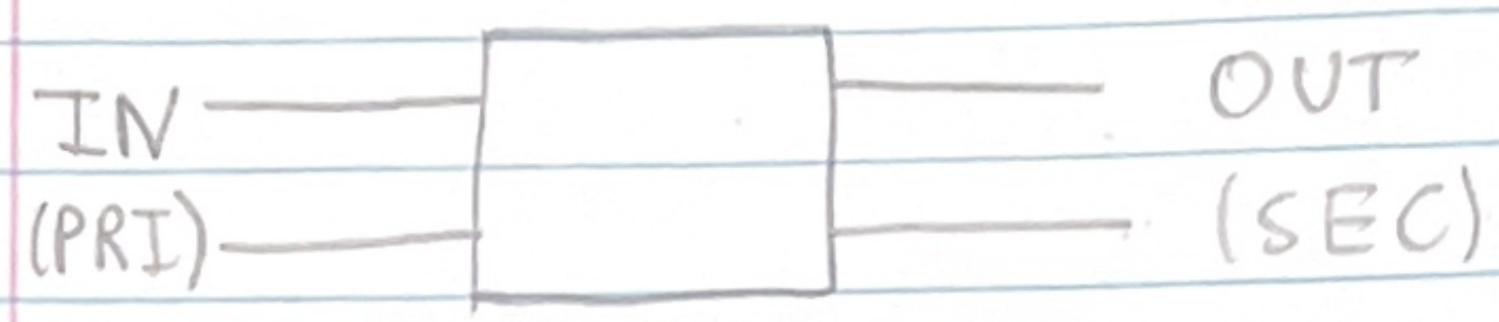
Ideal Transformer

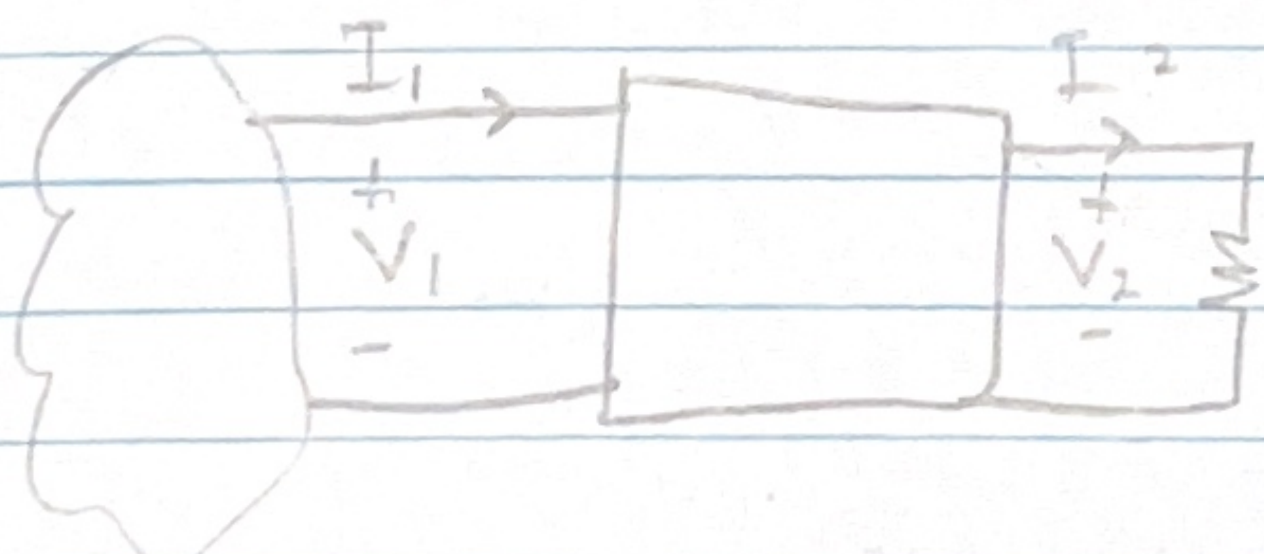


Step down

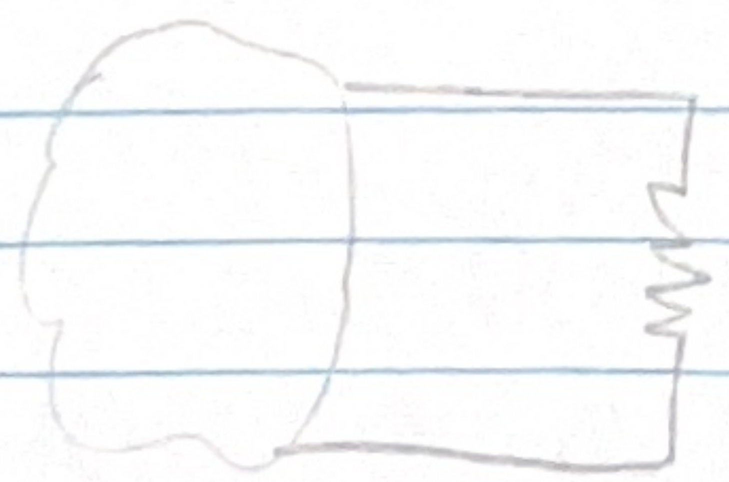
$V_1 = aV_2$ — Transformation ratio

$I_2 = aI_1$

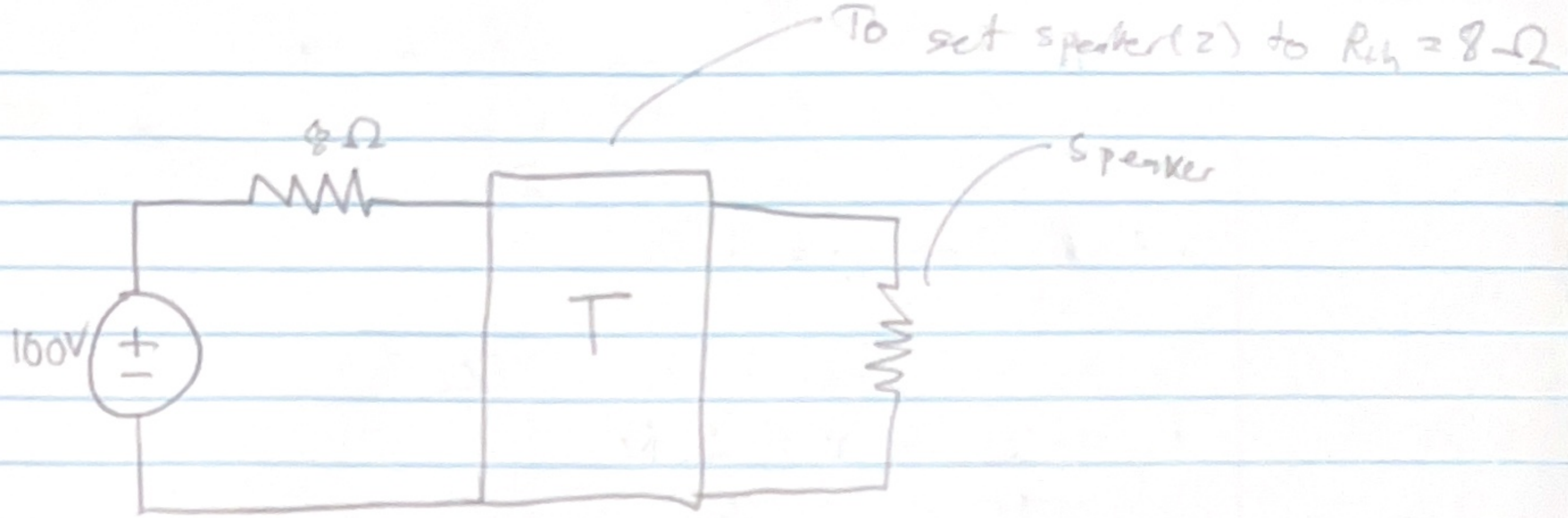
$$P_1 = V_1 I_1 = aV_2 \frac{I_2}{a} = V_2 I_2 = P_2$$



$$Z_2 = \frac{V_2}{I_2}$$



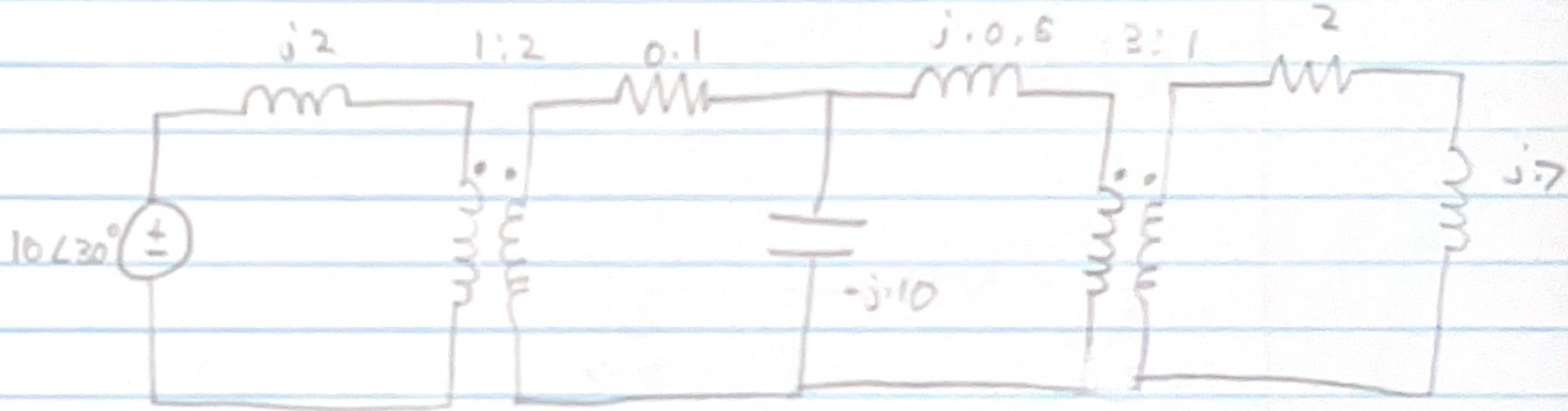
$$Z_1 = \frac{V_1}{I_1} = \frac{aV_2}{\frac{I_2}{a}} = a^2 Z_2$$

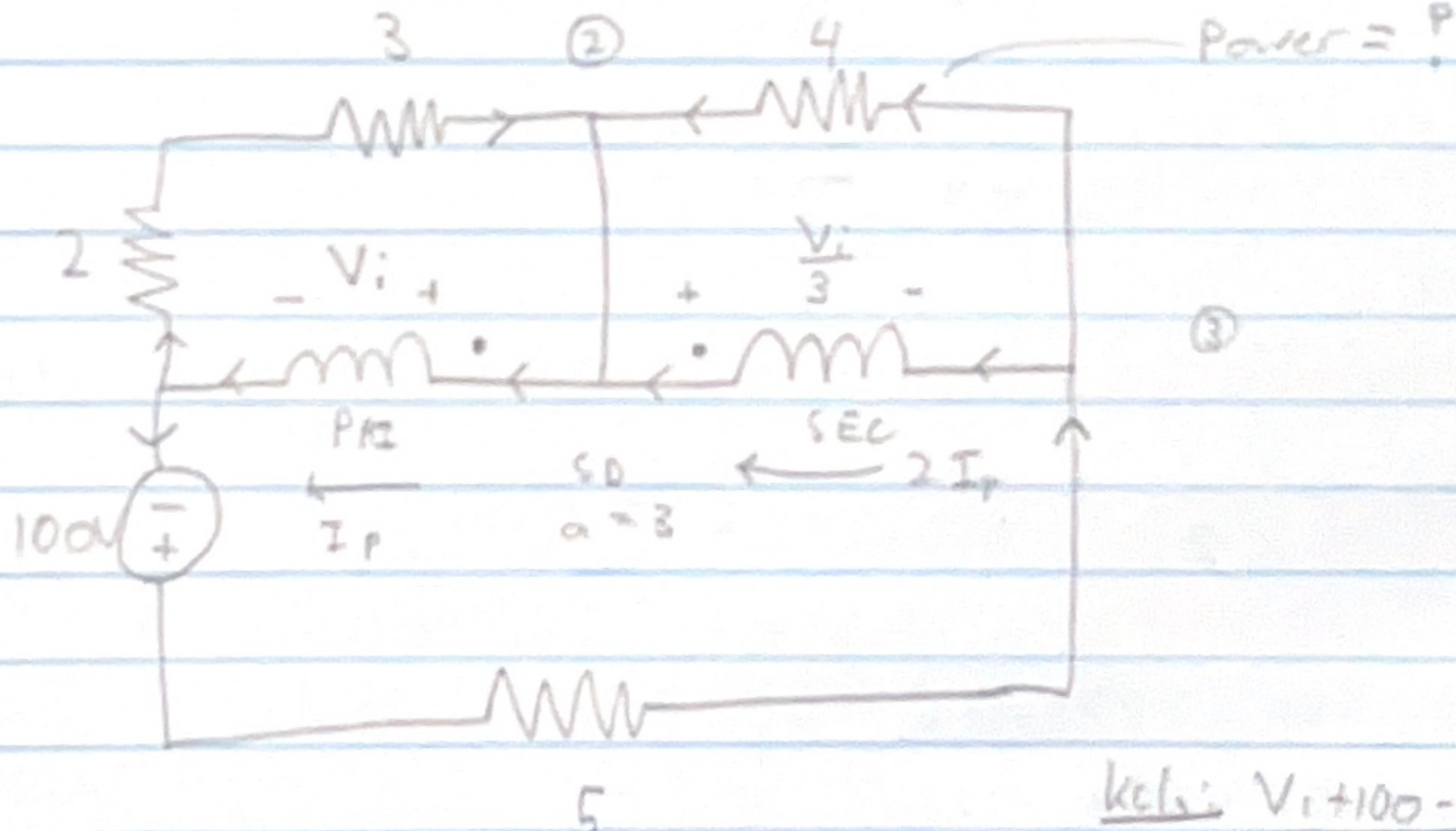


LV → HV :

- $V_s \cdot a$
- $I_s \div a$
- $Z \cdot a^2$

Tutorial





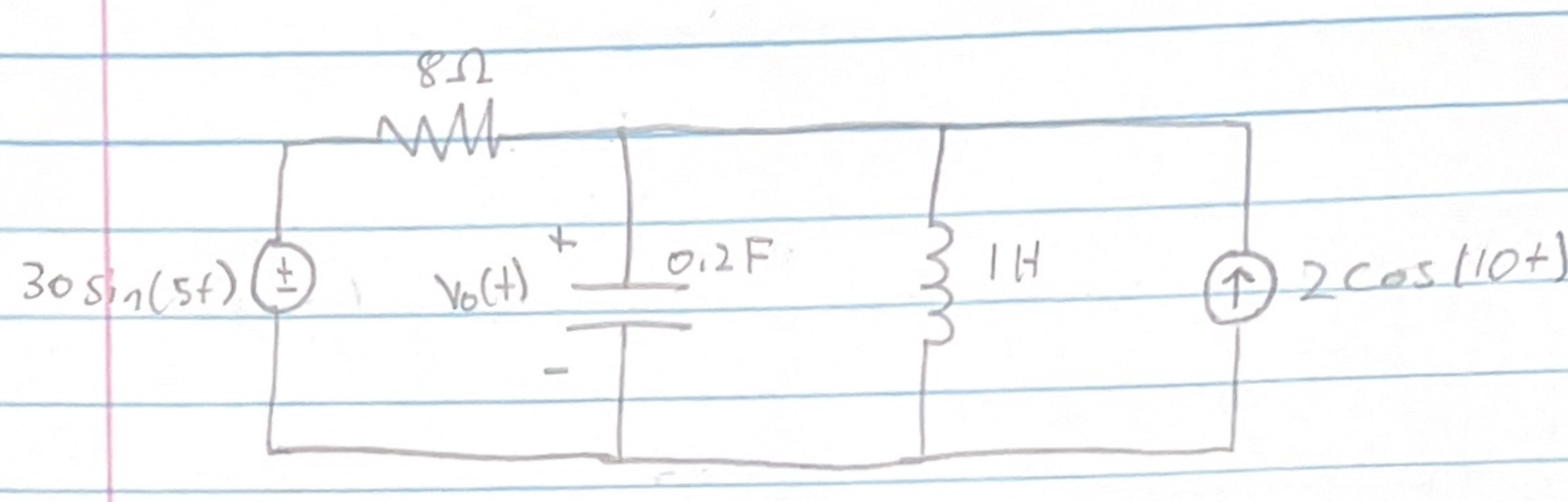
kcl₁: $\frac{V_1+100-V_3}{5} = 2I_p + \frac{V_3-V_2}{4}$

kcl₂: $I_p = \frac{0-V_2}{5} + \frac{0+100-V_1}{5}$

EVL: $V_2 - V_i = V_1$

kcl₂: $\frac{V_1-V_2}{5} + \frac{V_3-V_2}{4} + 2I_p = I_p$

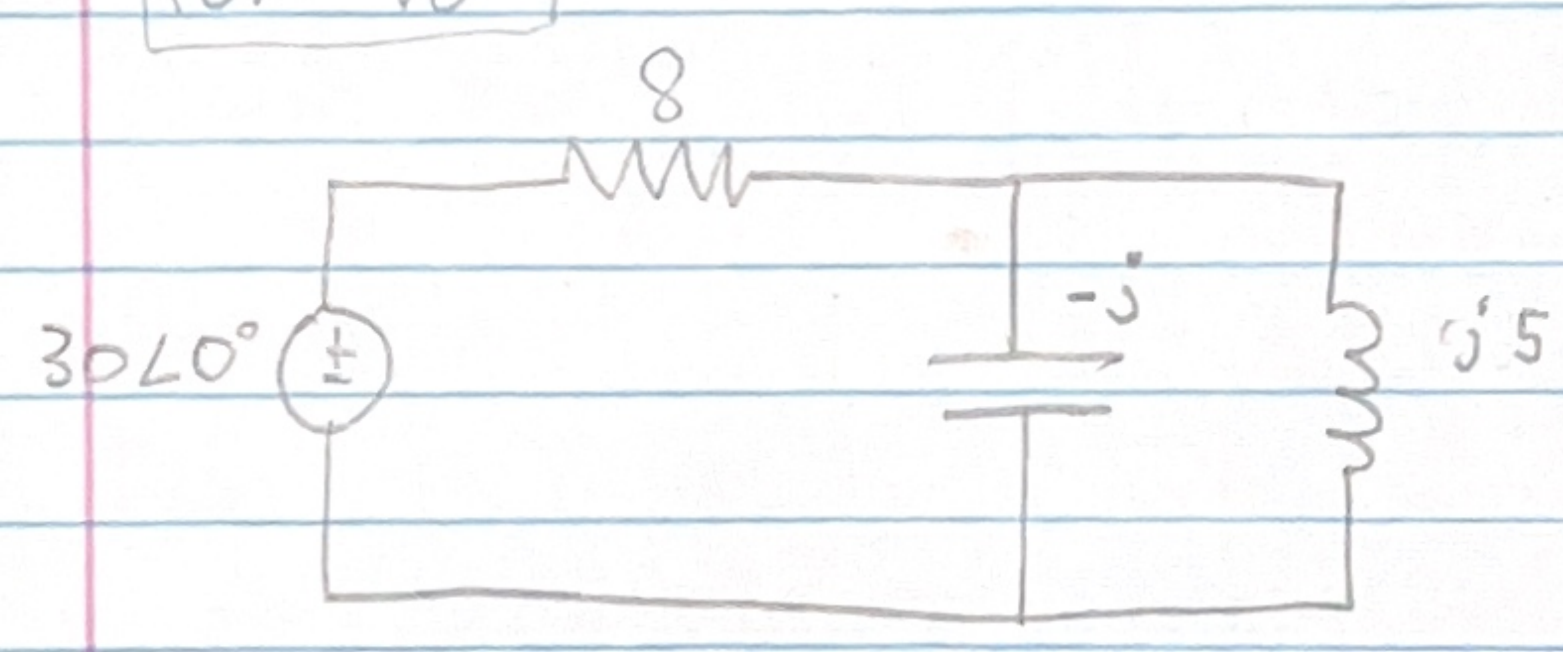
$\boxed{SS\ 2.13}$



Superposition $\rightarrow V_o = V_o' + V_o''$

V_o' (voltage source)
V_o'' (current source)

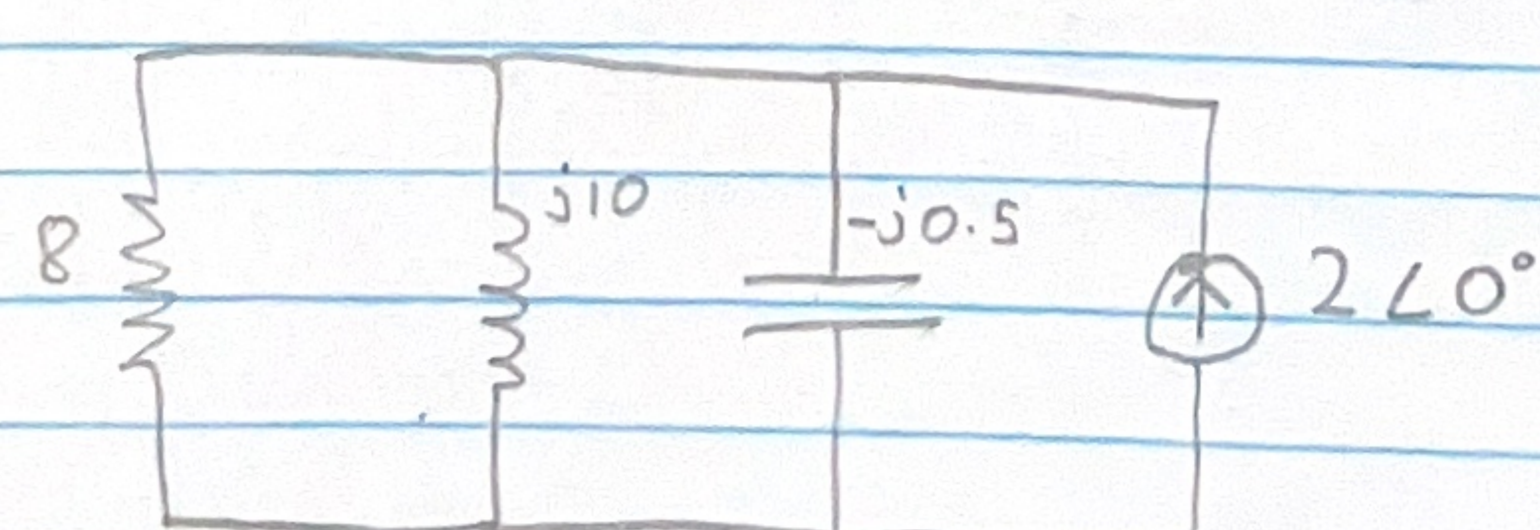
$\boxed{\text{for } V_o'}$



$$V_o' = \frac{-j \,//\, j5}{8 + (-j \,//\, j5)} \cdot 30 = 4.631\angle -81.12^\circ$$

$v_o'(t) = 4.631 \sin(5t - 81.12^\circ)\,V$

$\boxed{\text{For } V_o''}$ $\quad 2\cos(10t) \rightarrow 2\angle 0^\circ$



$$V_o'' = \frac{-j0.5}{8 \,//\, j10 + (-j0.5)} \cdot 2 \cdot (-j0.5)$$

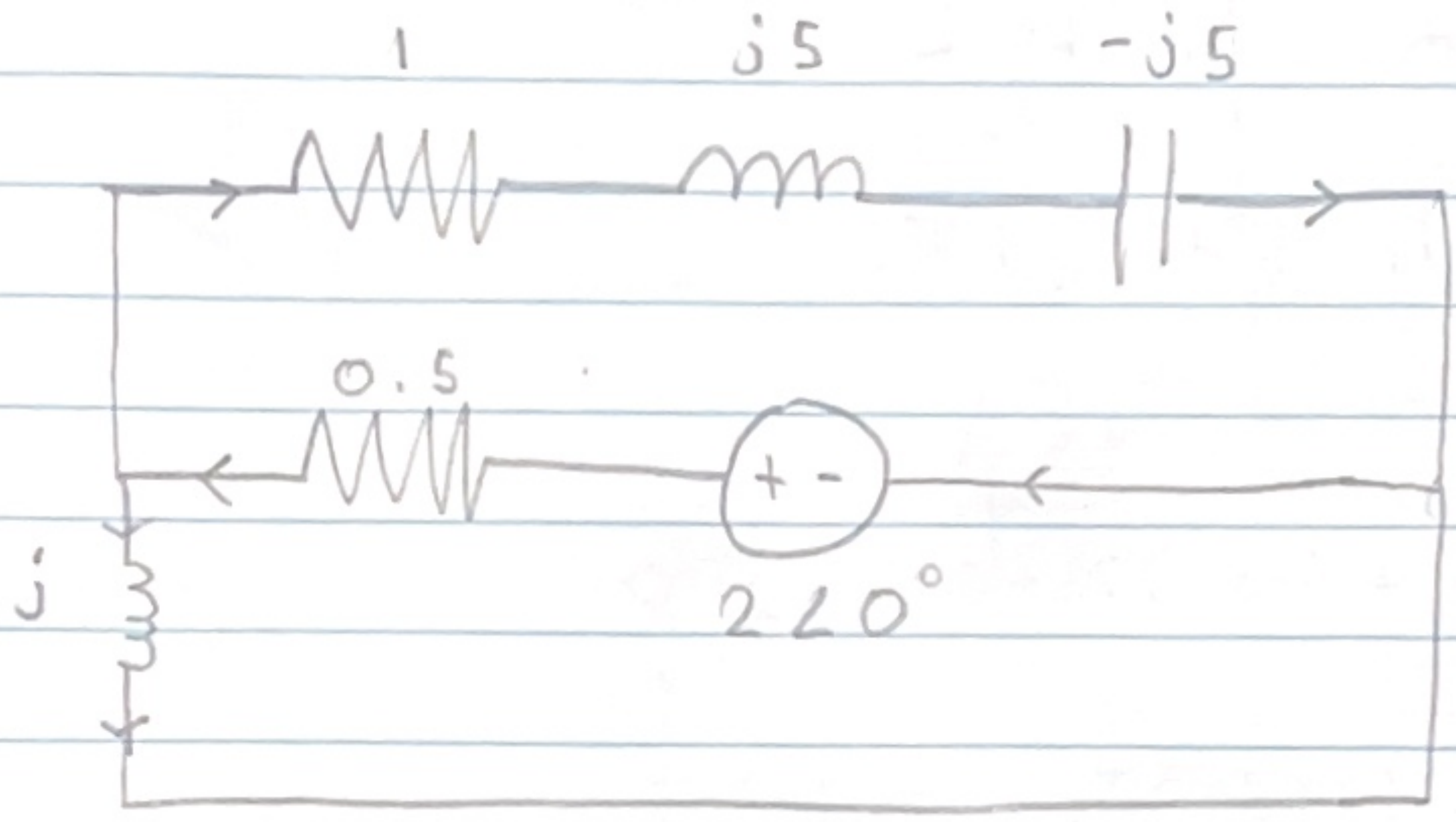
$$= 1.051\angle -86.24^\circ$$

$V_o''(t) = 1.051\cos(10t - 86.24°)V$

$\boxed{\text{Superposition}}$

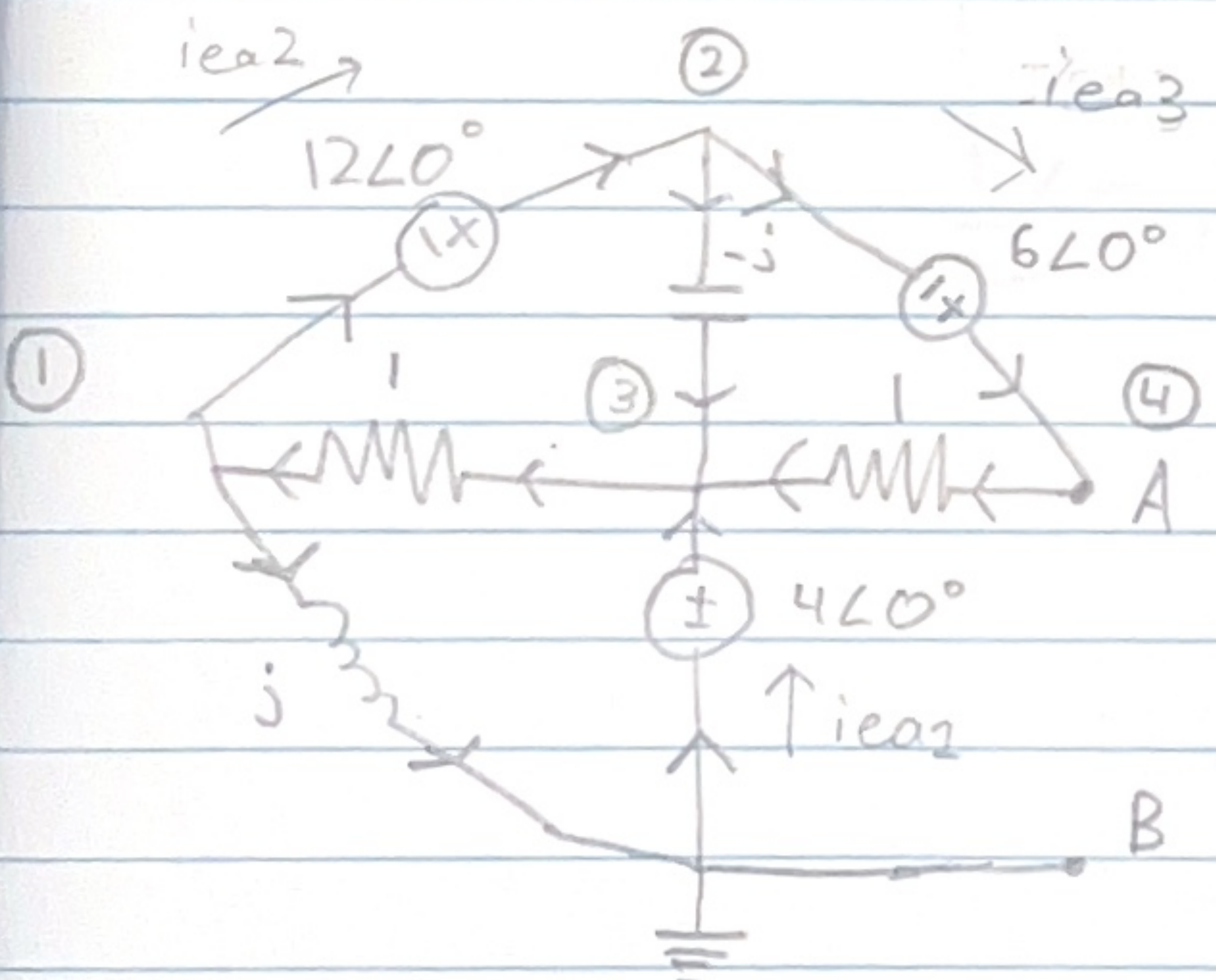
1.33
1.7

$V_o(t) = 4.631\sin(5t - 81.12°) + 1.051\cos(10t - 86.24°)$



REF

1 $V_o(t) = 3.92\cos(1000t - 71.31°)\ V$



EVL1: $V_1 + 12 = V_2$

EVL2: $0 + 4 = V_3$

EVL3: $V_2 + 6 = V_4$

KCl1: $(V_3 - V_1) = \dfrac{V_1}{j} + i_{ea}2$

KCl2: $i_{ea}2 = \dfrac{(V_2 - V_3)}{-j} + i_{ea}3$

KCl3: $(V_4 - V_3) + \dfrac{(V_2 - V_3)}{-j} + i_{ea}1 = (V_3 - V_1)$

KCl4: $i_{ea}3 = (V_4 - V_3)$ $V_4 = 13 - j4$

* $\boxed{TH2}$ $\boxed{V_{TH} = 13 - j4}$

Sinusodial Steady State

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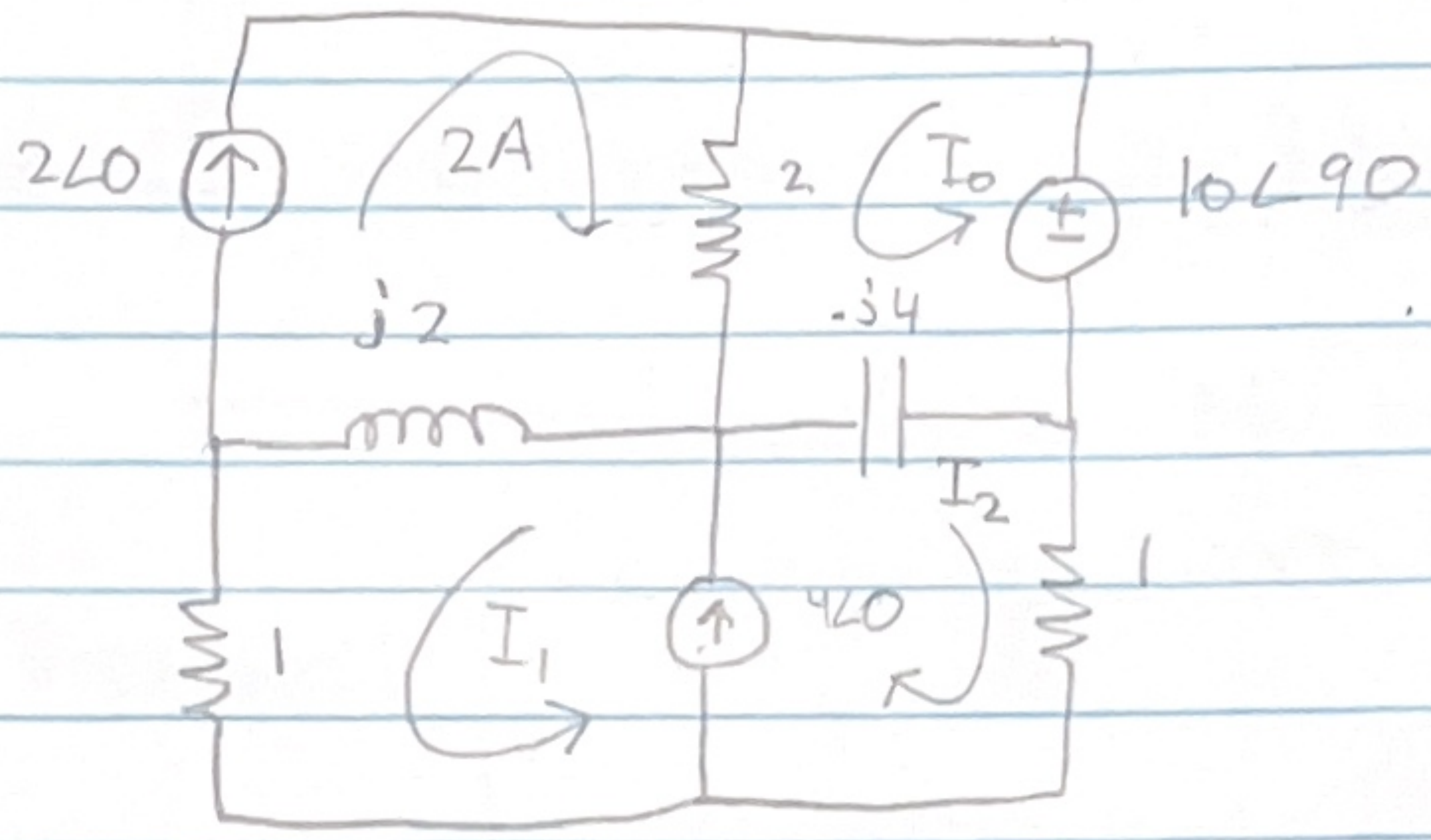
SS 3.6

Mesh Analysis:



KVL1: $(2-j4)I_o + (-j4)I_2 + 2\cdot 2 = j\cdot 10$

(Bottom Rect) KVL2: $-(-j4)I_o + (1+j2)I_1 - (1-j4)I_2 + j2\cdot 2 = 0$

KVL3: $I_1 + I_2 = 4$

Sol'n:

$I_o = 3.35 \angle 174.3° A$

$I_1 = 3.02 \angle -6.34° A$

$I_2 = 1.054 \angle 18.43° A$

AC Power

3/6/19
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$\boxed{SS\ 4.2}$

"power is the time rate of expending or absorbing energy"

Positive Power → element is absorbing power
Negative Power → element is supplying power

$\boxed{SS\ 4.3}$

$$p(t) = v(t)\,i(t) = \overbrace{V_m}^{\text{peak value}} \cos(\omega t + \theta_v)\, I_m \cos(\omega t + \theta_i)$$

Trig Identity

$$= \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) + \frac{1}{2} V_m I_m \cos(2\omega t + \theta_v + \theta_i)$$

$\boxed{SS\ 4.5}$

$$\frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$$

1. P_{avg} is not time dependent (it is constant)
2. When $\theta_v = \theta_i$ → it is a purely resistive load resulting in $P = \frac{1}{2} V_m I_m$
3. When $\theta_v - \theta_i = \pm 90°$ → $P = 0$ this is a purely reactive load

AC Power Analysis

3/11/19
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$\boxed{SS\ 5.2}$

Average Power:

$$P_{avg} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = \underbrace{V_{rms} I_{rms}}_{\text{apparent power}} \underbrace{\cos(\theta_v - \theta_i)}_{\text{power factor}}$$

$\boxed{SS\ 5.3}$

- Apparent power is $S = V_{rms} I_{rms}$
- Power factor $pf = \frac{P}{S} = \cos(\theta_v - \theta_i)$
- Power factor angle $= (\theta_v - \theta_i)$, or the angle of Z_{eq}

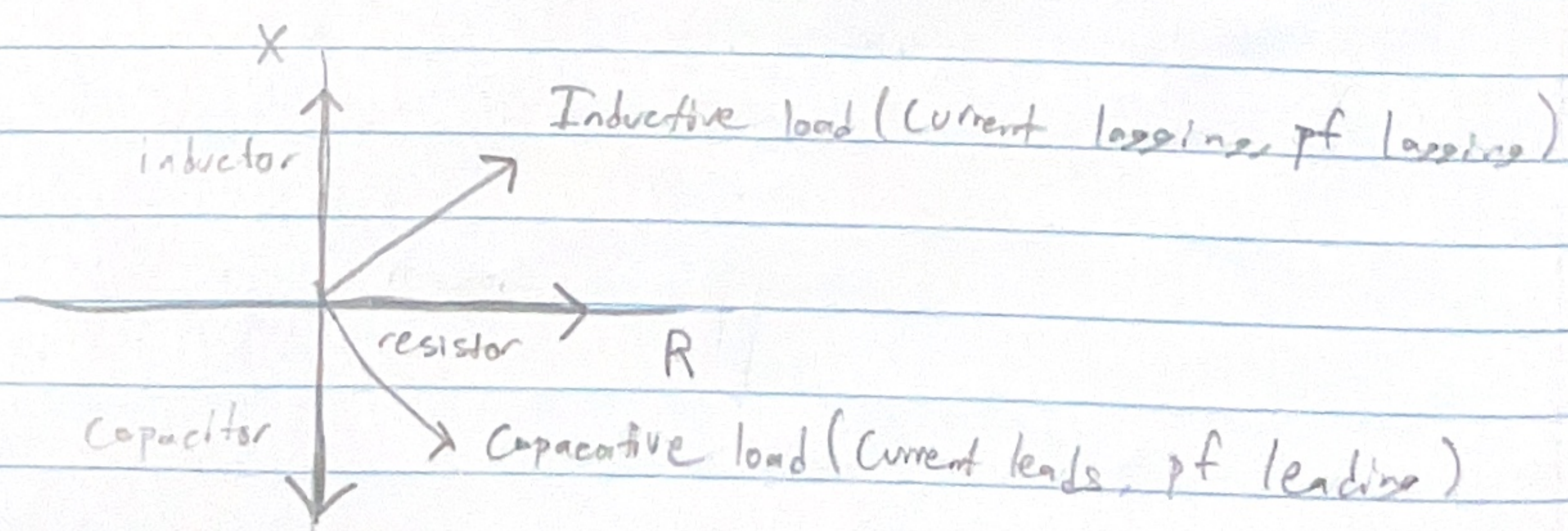
$\boxed{SS\ 5.4}$

$pf = \cos(\theta_v - \theta_i)$

$V = V_m \angle \theta_v$

$I = I_m \angle \theta_i$

$Z = \frac{V_m}{I_m} \angle \theta_v - \theta_i = \underset{\text{resistance}}{R} + j\underset{\text{reactance}}{X}$



$P_{avg} = V_{rms} I_{rms} \cdot (pf)$

Three Phase

3/18/19
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SS 7.6

$V_{an} = V_p \angle 0°$
$V_{bn} = V_p \angle -120°$ For abc sequence
$V_{cn} = V_p \angle -240°$
$= V_p \angle 120°$

SS 7.9

$$\left.\begin{aligned} V_{an} &= V_p \angle 0° \\ V_{bn} &= V_p \angle -120° \\ V_{cn} &= V_p \angle -240° \\ &= V_p \angle 120° \end{aligned}\right\} \text{phase Voltages}$$

$$\left.\begin{aligned} V_{ab} &= V_{an} - V_{bn} \\ &= V_p \angle 0° - V_p \angle -120° \\ &= V_p\left(1 + \tfrac{1}{2} + j\tfrac{\sqrt{3}}{2}\right) \\ &= \sqrt{3}\, V_p \angle 30° \\ V_{bc} &= V_{bn} - V_{cn} = \sqrt{3}\, V_p \angle -90° \\ V_{ca} &= \sqrt{3}\, V_p \angle -210° \end{aligned}\right\} \text{Line Voltages}$$

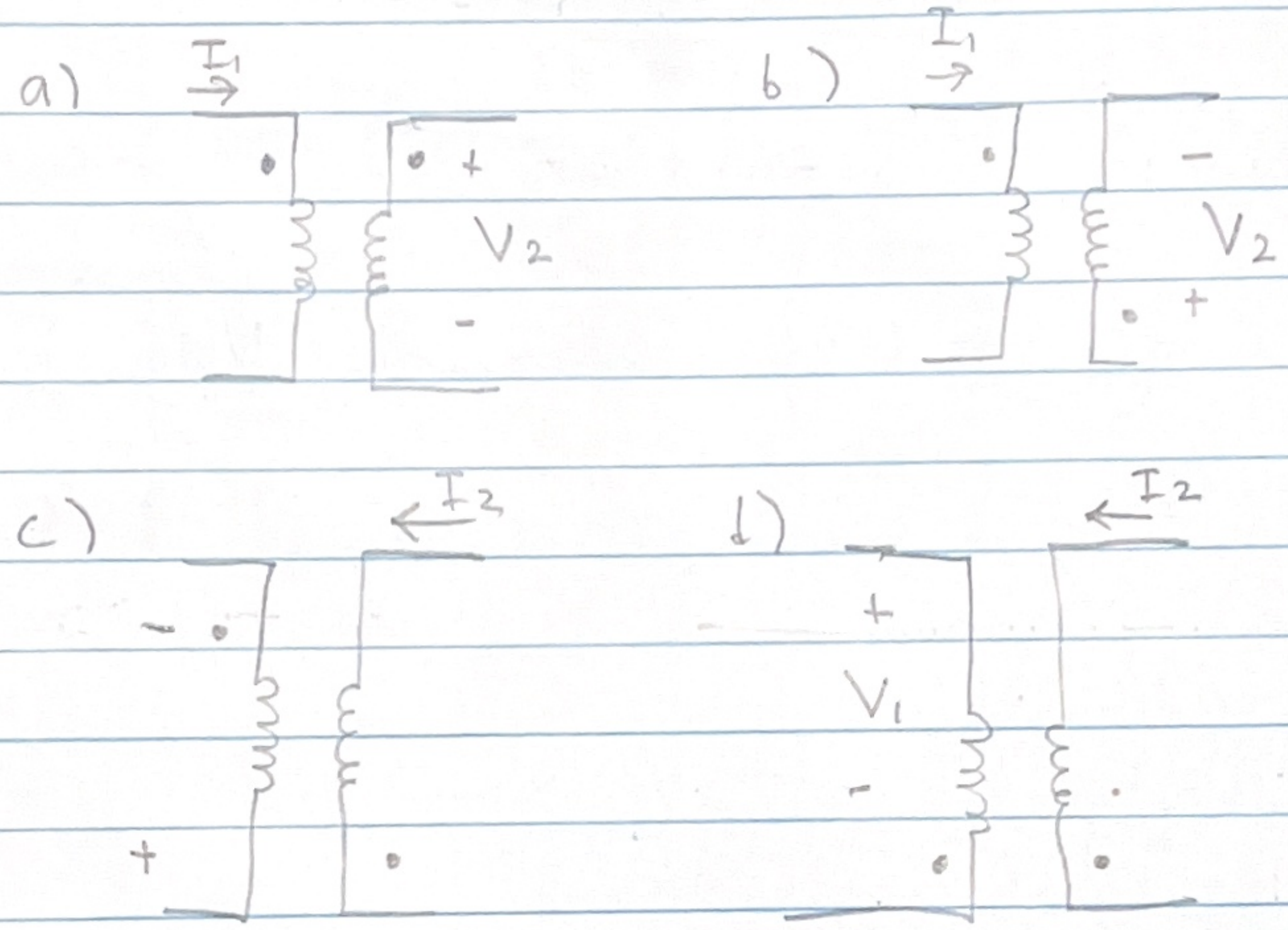
$V_p = |V_{an}| = |V_{bn}| = |V_{cn}|$

$V_L = |V_{ab}| = |V_{bc}| = |V_{ca}|$
$= \sqrt{3}\, V_p$

SS 8.5

- RHR
- Winding orientation affects mutual induction
- dot convention

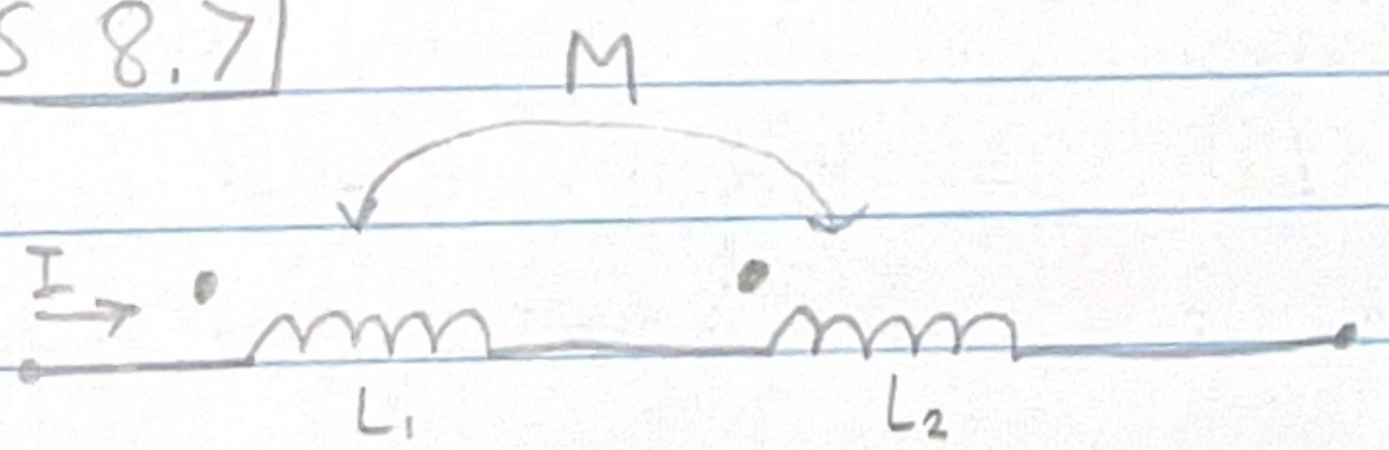
SS 8.6



"Self inductance induced voltage follows direction of current"

"Dot convention only applies to mutual induction"

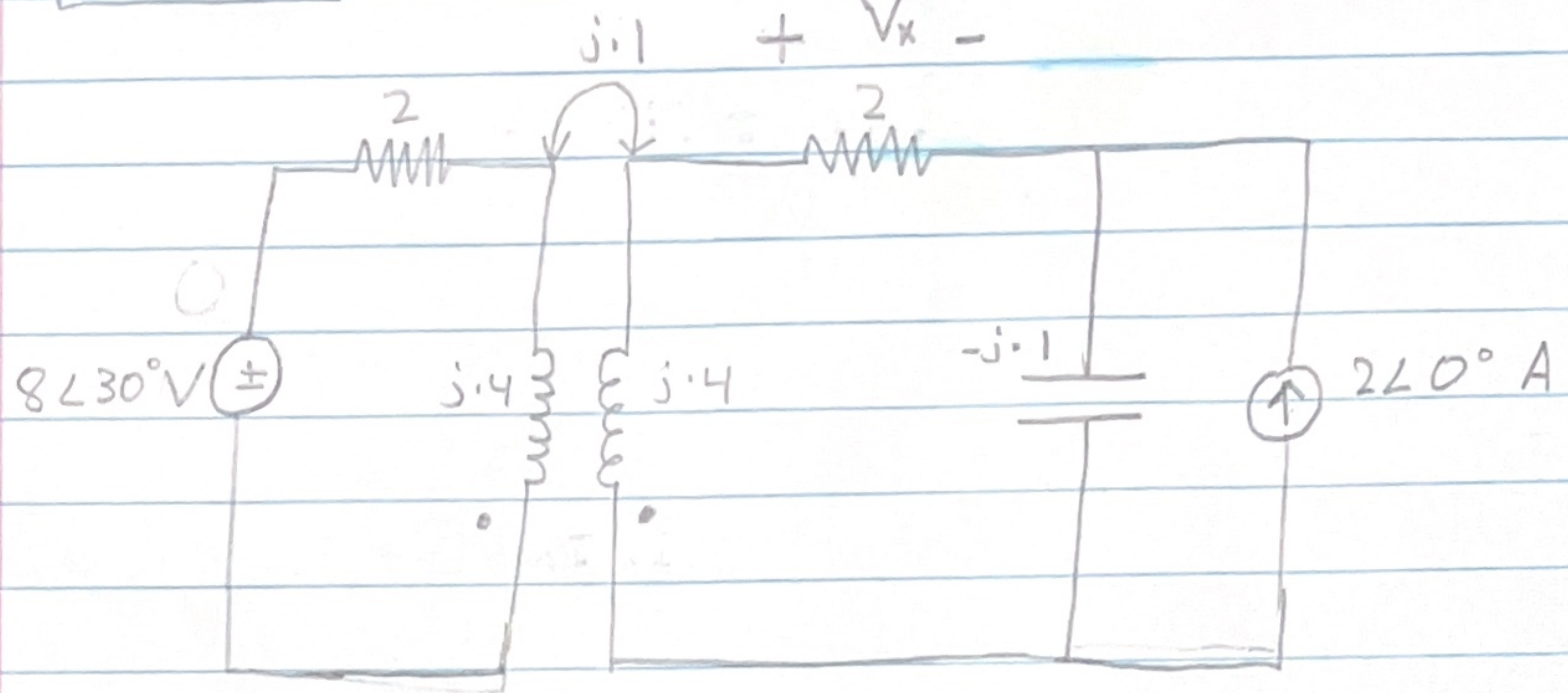
SS 8.7



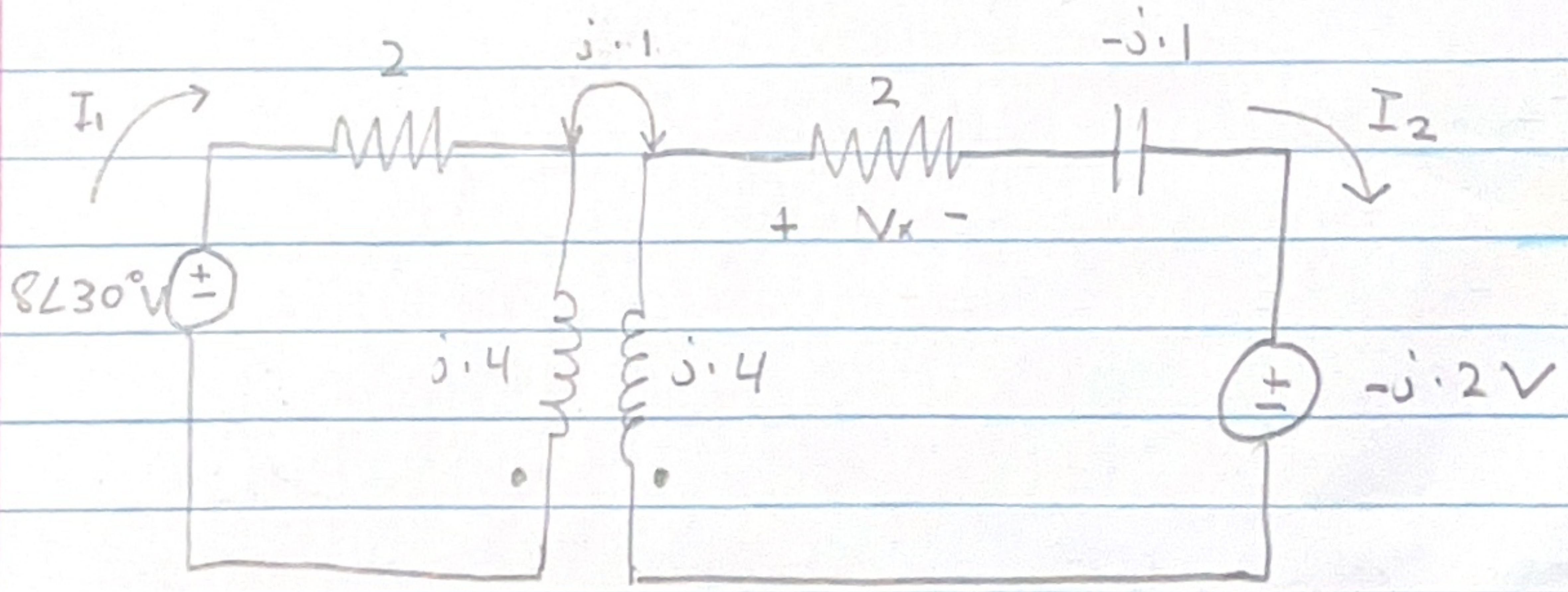
In Phasor Domain:

$Z_L = j\omega L$ | $Z_M = j\omega M$
$V = j\omega L \cdot I$ (Self inductance) | $V_M = j\omega M \cdot I$ (Mutual Inductan

$\boxed{SS\ 8.9}$ Find V_x



Source Transformation



KVL1: $8\angle 30° = 2I_1 + j\cdot 4 I_1 - j\cdot 1\cdot I_2$

KVL2: $j\cdot 4\cdot I_2 + (2 - j\cdot 1) I_2 - j\cdot 2 - j\cdot 1\cdot I_1 = 0$

$\longrightarrow I_2 = 1.037\angle 21.12°\ A$

$V_x = 2I_2 = 2.074\ \angle 21.12°\ V$