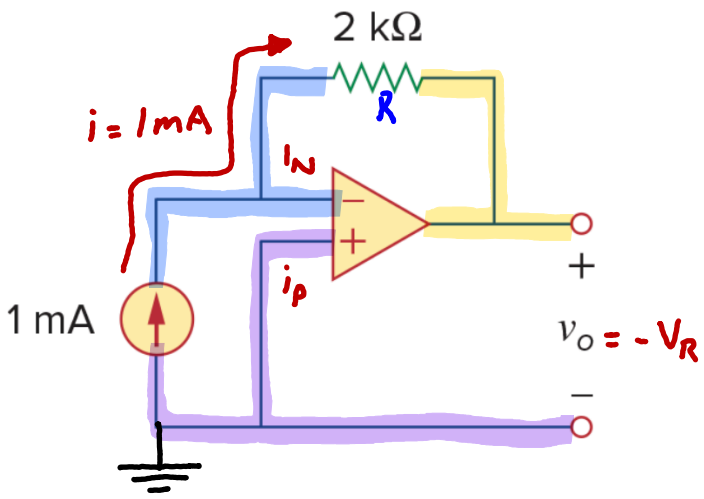
Homework 9
Due: Friday, April 14th, 2023 by 7PM.

Note: In order to receive full credit, you must show your work and carefully justify your answers. The correct answer without any work will receive little or no credit.

1. Find vo.



$R = 2k\Omega$

$V_R = 2000 \times .001 = 2V$

$V_o = -2V$

$i_p = i_N = 0$

$V_p = V_N$

No KCL @ output

2. Determine **Vo/Vs** given that C1 = C2 = 1nF, R1 = R2 = 100kΩ, R3 = 20kΩ, R4 = 40kΩ, and w = 2000 rad/sec.

$= 500kj$

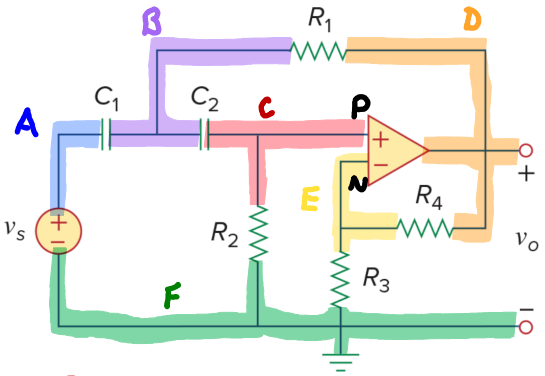
$i_p = i_N = 0$

$V_p = V_N$

No KCL@ output

$A = V_s$

$F = 0V$



KCL@ B

$i_{C1} = i_{C2} + i_{R1}$

$V_{C1} = V_s - V_B$

$V_{C2} = V_B - V_C$

$V_{R1} = V_B - V_D$

$\frac{V_{C1}}{500kj} = \frac{V_{C2}}{500kj} + \frac{V_{R1}}{100k}$

$\frac{V_{C1} - V_{C2}}{500kj} = \frac{V_{R1}}{100k}$

$V_{C1} - V_{C2} = 5j V_{R1}$

$V_s - 2V_B + V_C = 5jV_B - 5jV_D$

$V_s - V_B(2+5j) + V_C + 5jV_D = 0$

KCL@ C:

$i_{C2} = i_{R2}$

$\frac{V_{C2}}{500kj} = \frac{V_{R2}}{100k}$

$V_{C2} = 5jV_{R2}$

$V_B - V_C = 5jV_C$

$V_B - V_C(1+5j) = 0$

KCL@ E:

$i_{R4} = i_{R3}$

$\frac{V_{R4}}{40k} = \frac{V_{R3}}{20k}$

$V_{R4} = 2V_{R3}$

$V_D - V_E = 2V_E$

$V_D - 3V_E = 0$

$V_{R4} = V_D - V_E$

$V_{R3} = V_E$

$V_{R2} = V_C$

V_s	V_B	V_C	V_D	V_E	x
1	$-2-5j$	1	$5j$	0	0
0	1	$-1-5j$	0	0	0
0	0	0	1	-3	0
↓					
1	0	51	0	$15j$	0
0	1	$5j$	0	0	0
0	0	0	1	-3	0

3. Obtain **Vo** for the op-amp circuit below:

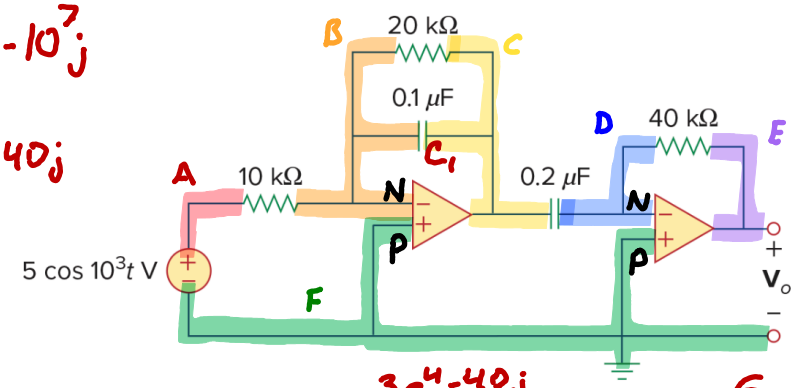
$i_p = i_N = 0$

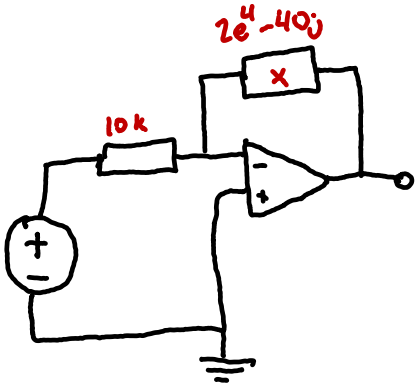
$V_p = V_N$

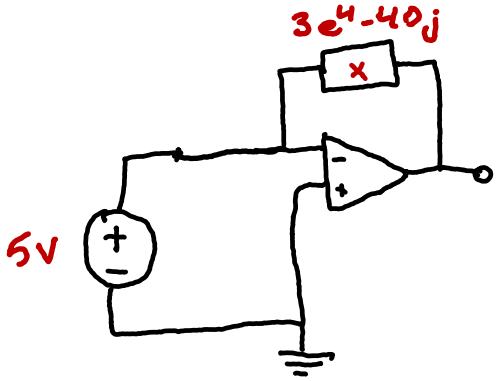
No KCL @ output

$C_1 = \frac{-j}{(0.1\times10^{-9})(10^3)} = -10^7 j$

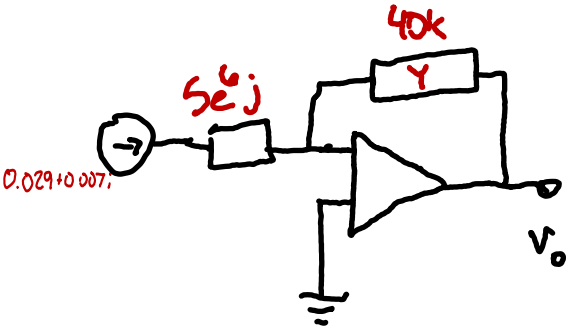
$X = \frac{1}{\frac{1}{20k} + \frac{1}{-10^7 j}} = 20000 - 40j$



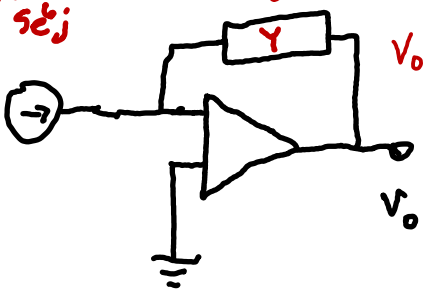




$i_x = \frac{5}{3e^4 - 40j} = 0.029 + 0.007j$



$Y = \frac{1}{\frac{1}{40k} + \frac{1}{5e^6 j}} = 101.464 + 2012.03j$

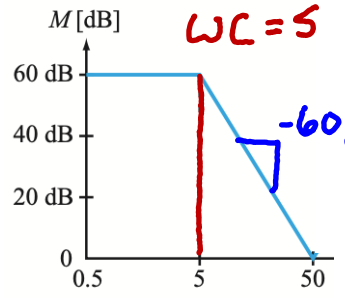


$V_o = (0.029 + 0.007j)(101.464 + 2012.03j)$

$V_o = -11.232 + 58.676j$

4. For the bode plot below:
   A. What is the transfer function that represents this plot?
   B. Design a filter connected for the transfer function found in part A. Clearly specify the circuit drawing and pick realistic values for the resistors and capacitors.

poles: 5, 5, 5



$\omega C = 5$

$k = \text{gain} = \frac{V_{out}}{V_{in}} = \frac{R_F}{R_S}$

-60 dB/decade

$60 = 20\log_{10}(k)$

$3 = \log_{10}(k)$

$10^3 = k$

$\frac{R_F}{R_S} = 1000 = \text{gain}$

$H(j\omega) = \frac{1000}{1 + .2j\omega}$

$\left(\frac{10}{1 + j\omega RC}\right)^3$

$\frac{j\omega}{5}$

$\omega = \frac{1}{RC}$

$5 = \frac{1}{CR_F}$

	1	2	3
C	1μ	2μ	3μ
R_F	200k	100k	66k