Texas A&M University
Department of Electrical and Computer Engineering

ECEN 325 – Electronics

Spring 2021

Exam #1

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are **6** pages in your exam
- Good Luck!

Problem	Score	Max Score
1		30
2		25
3		25
4		20
Total		**100**

Name: SAM PALERMO

UIN: ____________________

Problem 1 (30 points)

Plot the magnitude and phase response of the following transfer function. Label key points and slopes.

$$H(s) = \frac{100s(s+10^5)}{(s+10^4)(s+10^6)}$$

DC gain = ϕ = $-\infty$ dB

HF gain = 100 = 40dB

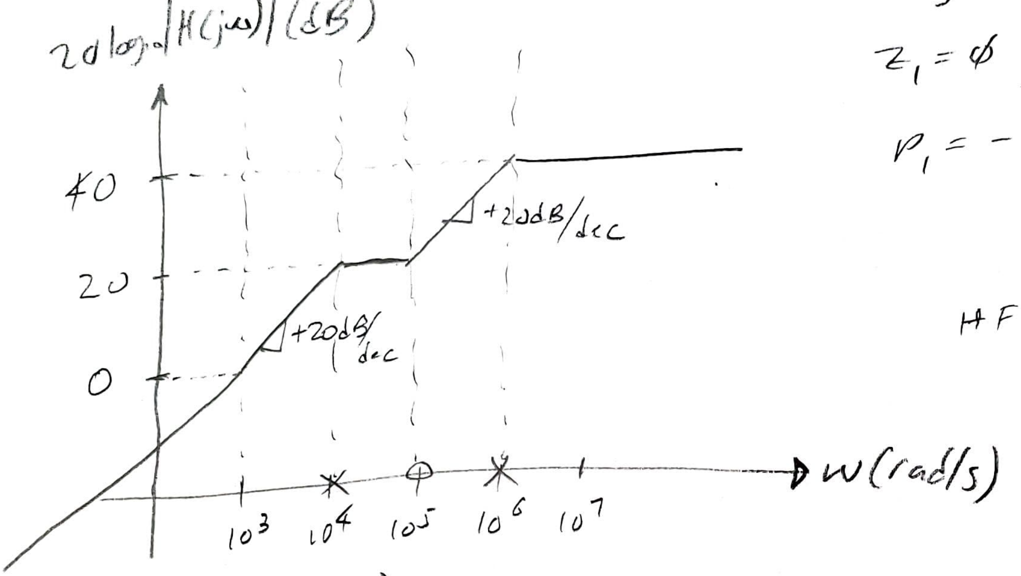
$z_1 = \phi$, $z_2 = -10^5$

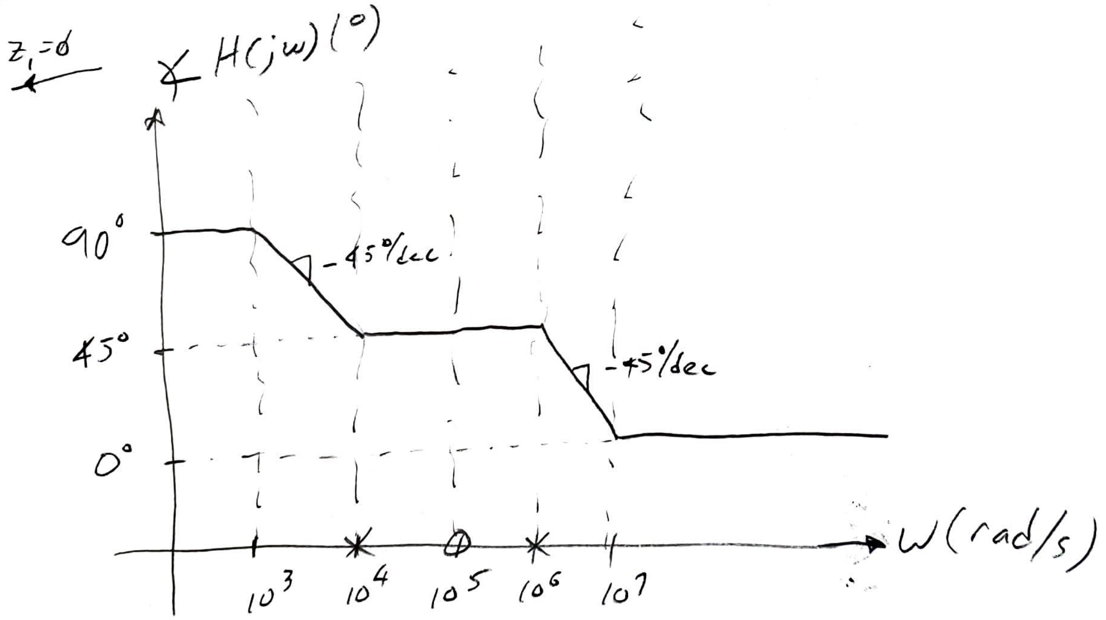
$p_1 = -10^4$, $p_2 = -10^6$

LF Phase = 90°

HF Phase = $90^\circ + 1(90^\circ) + 2(-90^\circ)$

= 0°





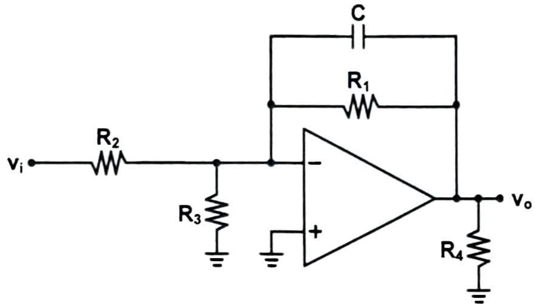
Problem 2 (25 points)

Assume for Problem 2 circuits that all operational amplifiers are ideal.

For the following circuit:

i. Obtain the transfer function, $v_o(s)/v_i(s)$

ii. Set the component values to achieve a 100Ω input resistance, 40dB low-frequency gain (magnitude), and a pole frequency of $|\omega_p| = 100$krad/s.



$$\frac{V_o}{V_i} = -\frac{Z_{R1} \| Z_C}{Z_{R2}} = -\frac{1}{\left(\frac{1}{R_1} + sC\right)R_2} = \frac{-\frac{R_1}{R_2}}{1 + sR_1C}$$

$$\boxed{\frac{V_o}{V_i} = \frac{-\frac{R_1}{R_2}}{1 + sR_1C}}$$

$$R_{in} = R_2 = 100\Omega$$

$$|LF\ gain| = 40dB = 100 \Rightarrow R_1 = 100R_2 = 100(100) = 10k\Omega$$

$$|\omega_p| = \frac{1}{R_1C} = 100krad/s$$

$$C = \frac{1}{R_1|\omega_p|} = \frac{1}{(10k\Omega)(100krad/s)} = 1nF$$

$R_1 = 10k\Omega$

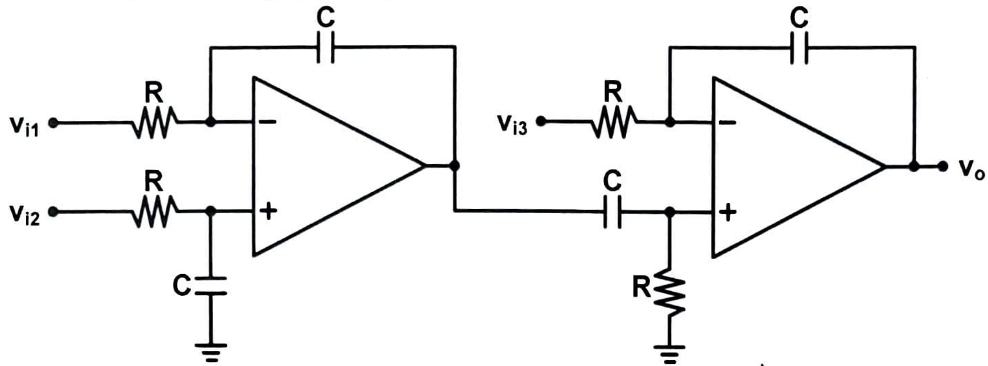
$R_2 = 100\Omega$

$C = 1nF$

Problem 3 (25 points)

Assume for Problem 3 circuits that all operational amplifiers are ideal.

For the following circuit obtain the expression for v_o as a function of v_{i1}, v_{i2}, and v_{i3}. Assume ideal opamps. Hint: apply superposition.



$$V_o = -\left(\frac{Z_C}{Z_R}\right)\left(\frac{Z_R}{Z_R + Z_C}\right)\left(1 + \frac{Z_C}{Z_R}\right) V_{i1}$$

$$+ \left(\frac{Z_C}{Z_R + Z_C}\right)\left(1 + \frac{Z_C}{Z_R}\right)\left(\frac{Z_R}{Z_C + Z_R}\right)\left(1 + \frac{Z_C}{Z_R}\right) V_{i2}$$

$$- \left(\frac{Z_C}{Z_R}\right) V_{i3}$$

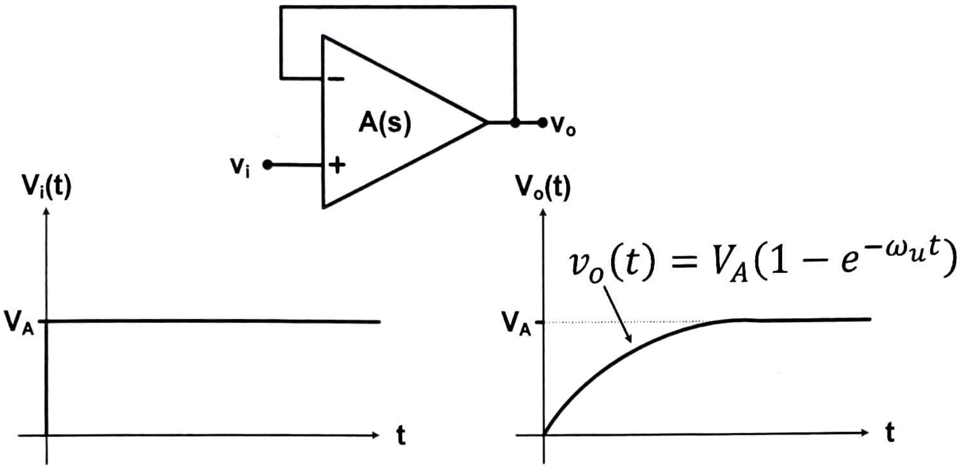
$$V_o = -\left(\frac{Z_C}{Z_R}\right) V_{i1} + \frac{Z_C}{Z_R} V_{i2} - \frac{Z_C}{Z_R} V_{i3}$$

$$\boxed{V_o = \frac{1}{sRC}\left[-V_{i1} + V_{i2} - V_{i3}\right]}$$

Problem 4 (20 points)

The step response of a unity-gain voltage follower constructed with a single-pole opamp with unity gain frequency, ω_u, is given below. The operational amplifier for this problem has a finite slew rate of 10V/μs. Given an input step amplitude V_A=5V, what is the maximum opamp unity gain frequency, ω_u, that the opamp can have and still produce an un-distorted single-pole transient step response?

$$A(s) = \frac{\omega_u}{s + \omega_1}$$



$$\max\left(\left|\frac{dV_o(t)}{dt}\right|\right) \le SR$$

$$\frac{dV_o(t)}{dt} = V_A W_u e^{-W_u t}$$

$$\max\left(\left|\frac{dV_o(t)}{dt}\right|\right) = V_A W_u \le SR$$

$$W_u \le \frac{SR}{V_A} = \frac{10\,V/\mu s}{5V} = 2\,Mrad/s$$

Max ω_u = 2 Mrad/s