EE140 HW5 Solutions

① $$\frac{A_o}{1+A_o f} - \frac{1}{f} = \frac{A_o f - (1+A_o f)}{f(1+A_o f)} = \frac{-1}{f(1+A_o f)}$$

$$\frac{\frac{-1}{f(1+A_o f)}}{\frac{1}{f}} = \frac{-1}{1+A_o f} \approx \frac{-1}{A_o f}$$

Reasonable approximation for large A_o.

#1) 2 pts

② $A_o = 10^4$ $\omega_p = 10^6$ rad/s $f = 0.1$

a) $$\frac{A_o}{1+A_o f} = \frac{10^4}{1+10^4 10^{-1}} = 9.99 \text{ V/V}$$

#2) 8 pts total
2 pts for each part

b) $$\frac{1}{f} = 10 \text{ V/V}$$

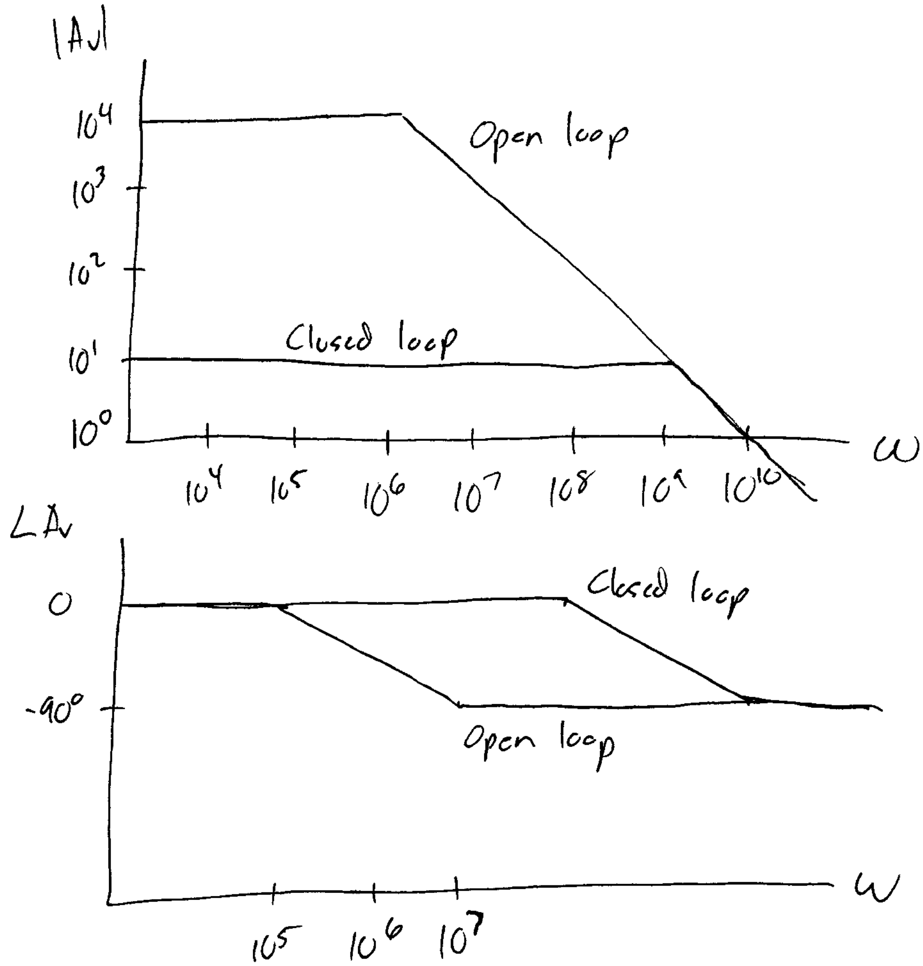
c) $$\frac{-1}{A_o f} = \frac{-1}{10^4 10^{-1}} = -0.001$$

d) @ $10\omega_p$ gain decreases $10\times$, so $\frac{-1}{Af} = -0.01$

@ $100\omega_p$ gain decreased $100\times$, so $\frac{-1}{Af} = -0.1$

3

a,b



#3) 12 pts total
a) 3 pts: 1 each for magnitude, pole frequency, -45 degrees at pole frequency
b) 3 pts: same as (a)
c) 2 pts
d) 2 pts
e) 2 pts

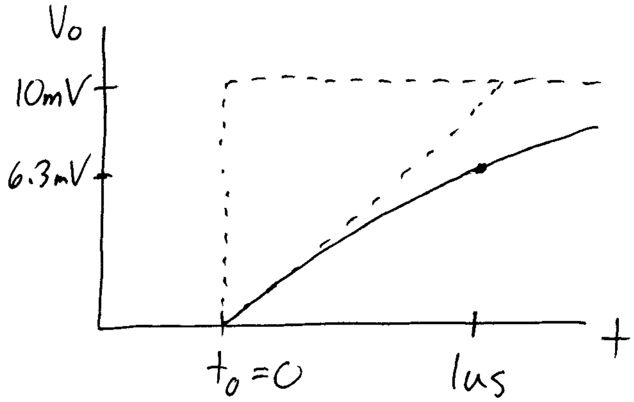
c) Open loop unity gain = 10^{10} rad/s
Closed loop unity gain is also 10^{10} rad/s

d) Open loop pole is 10^6 rad/s
Closed loop pole is 10^9 rad/s

e) Gain Bandwidth product is 10^{10} rad/s in both open and closed loop.

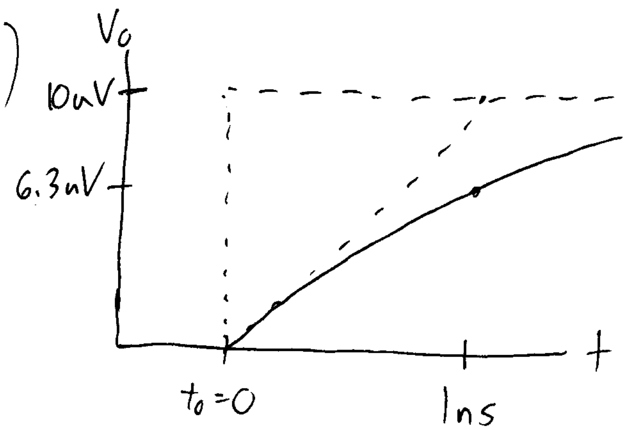
4) a) $\tau = 1\mu s$ for open loop $\left(\frac{1}{10^6}\right)$

b)



c) $\tau = 1ns$ for closed loop

d)

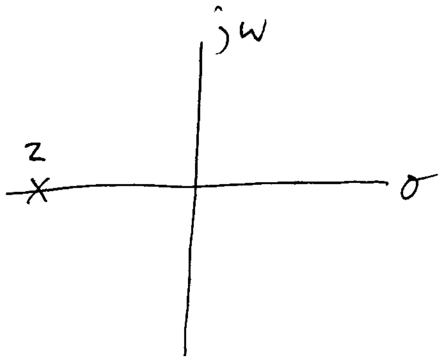


e) Part (d) would look like a straight vertical line on the axis used for part (b), And it only goes up to 10uV instead of 10mV.

#4) 8 pts total
a) 1 pt
b) 2 pts, must show exponential and correct final value
c) 1 pt
d) 2 pts, same as (b)
e) 2 pts, much steeper, different final value

(5) a) see attached plot

b)



Both poles are on the negative real axis at 10^6 rad/s.

#5) 10 pts total
a) 4 pts, 1 each for magnitude, pole frequency, 1/w^2 rolloff, -90 deg at poles
b) 2 pts
c) 2 pts
d) 2 pts

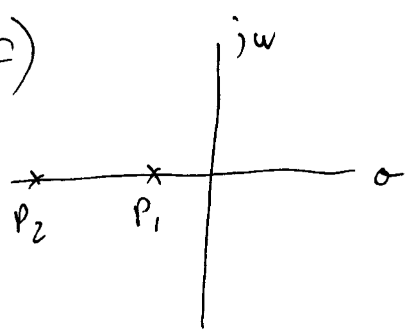
c) $f = 1$ gives a phase margin of $0°$

d) No, it will technically not oscillate with only two poles, but in reality it will due to other high frequency poles.

(6) (a) - (e) See attached plots

#6) 21 pts total
a) 2 pts, 1 each for magnitude, pole frequency
b) 4 pts: low frequency capacitance, high frequency capacitance, pole+zero frequencies
c) 4 pts: 1 for each region
d) 2 pts: getting the low frequency gain right; shape should be the same as 6c
e) 3 pts: low freq gain, 1st pole, 2nd pole
f) 2 pts
g) 2 pts
h) 2 pts

f)



$P_1 = 10^4$ rad/s

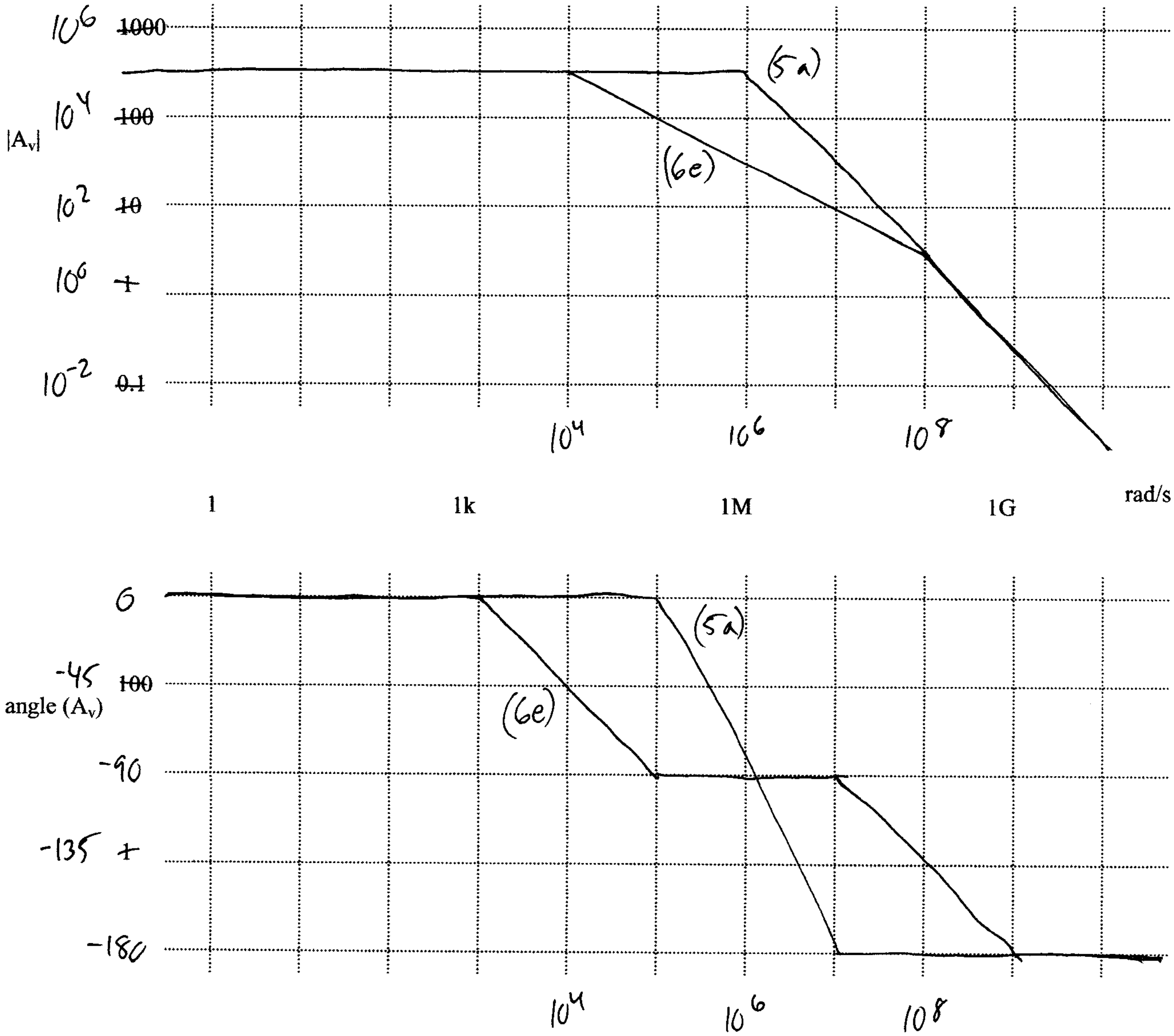
$P_2 = 10^8$ rad/s

g) ω_u is $\sqrt{10} \approx 3\times$ past $\omega_{p2} \approx 3 \cdot 10^8$ rad/s

$PM = 180° - 90° - \tan^{-1}(\sqrt{10}) \approx 18°$

h) It is stable, but this is a pretty low phase margin.

Bode plot for problem 5a) and 6e)



#7) 8 pts total (EE240 only)

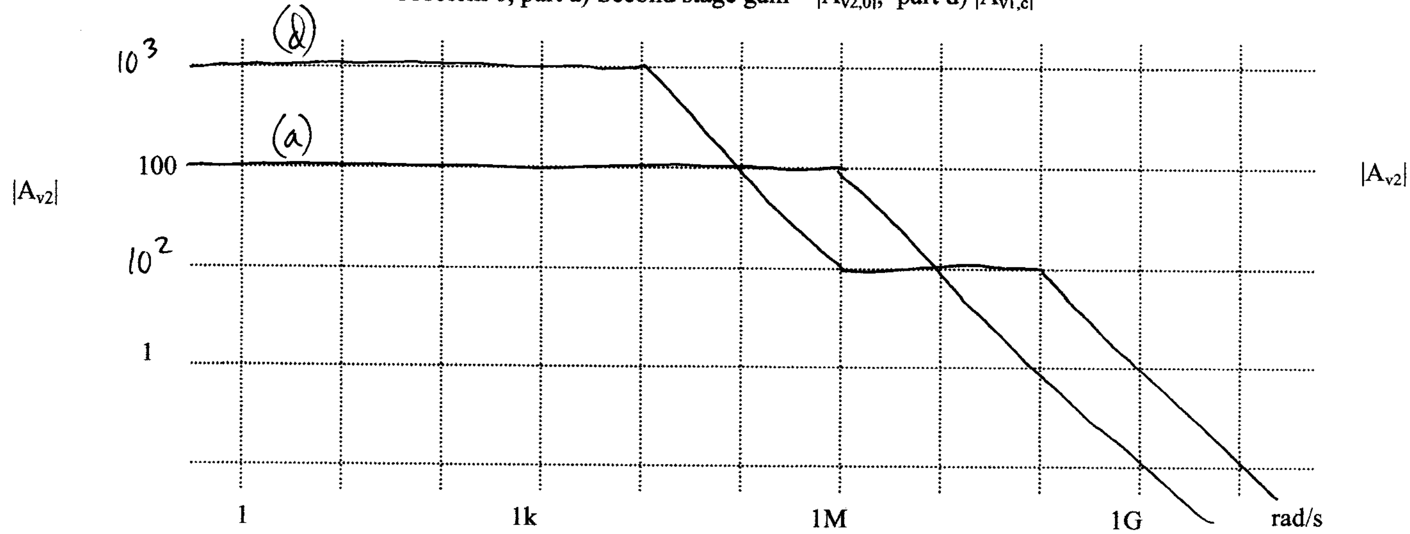
+2 pts Expected gain error from f

+2 pts Does it depend on f

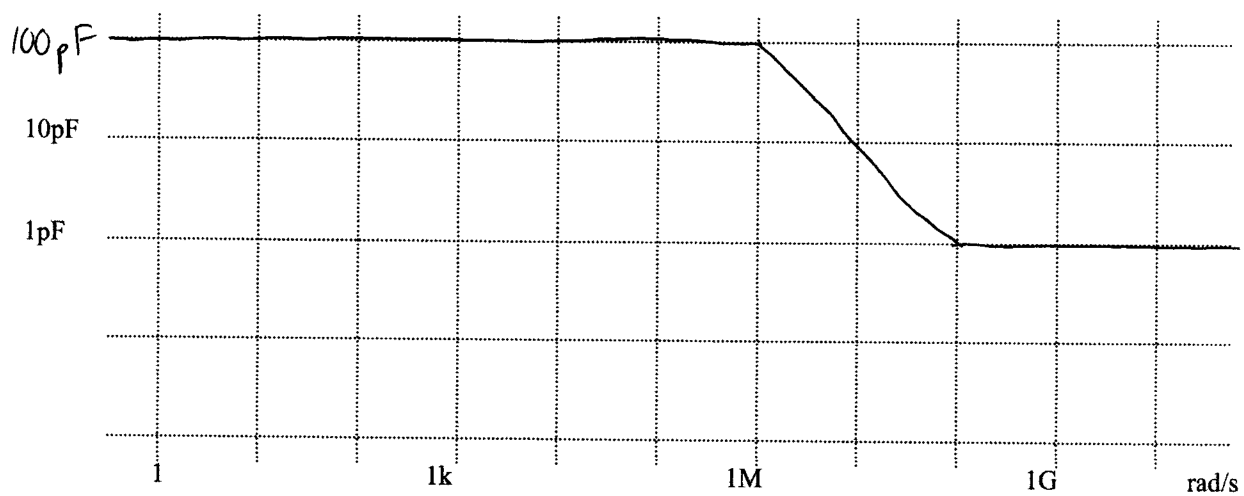
+2 pts Temp difference for same error

+2 pts Minimum gain necessary

Problem 6, part a) Second stage gain – $|A_{v2,0}|$; part d) $|A_{v1,c}|$



problem 6, part b) magnitude of second stage input (Miller) capacitance



problem 6, part c) second stage input impedance, and R_{o1}