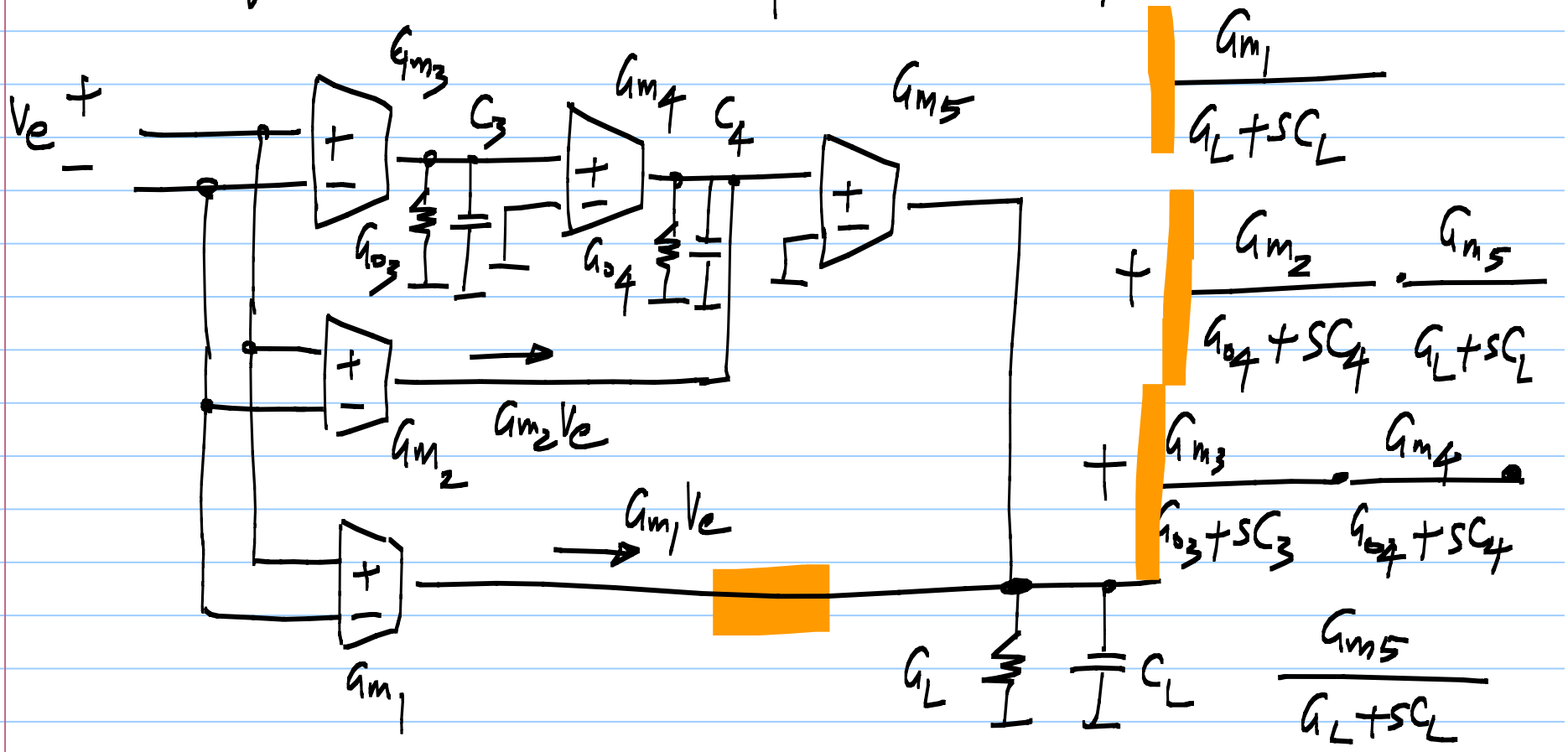
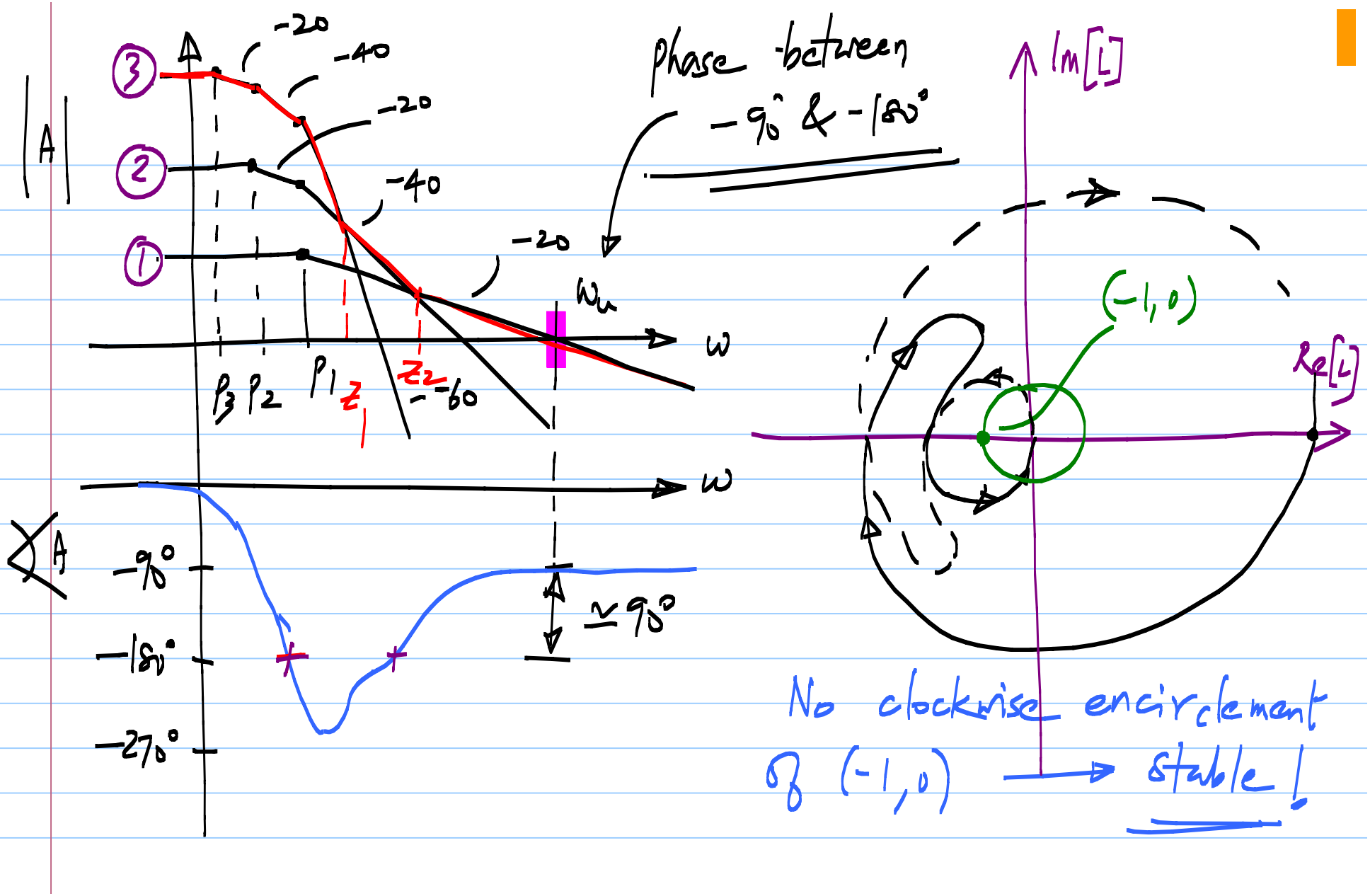
Lecture 17

Three stage feedforward compensated opamp:




|A|
-20
-40
-20
-40
-20
3
2
1
ω_u
ω
p_3 p_2 p_1 z_1 z_2 -60
ω
$\angle A$
-90°
-180°
-270°
$\sim 90°$
phase between
-90° & -180°
Im[L]
Re[L]
(-1, 0)
No clockwise encirclement
of (-1, 0) → stable!

(loop gain)

Phase shift = $-180°$ & magnitude > 1

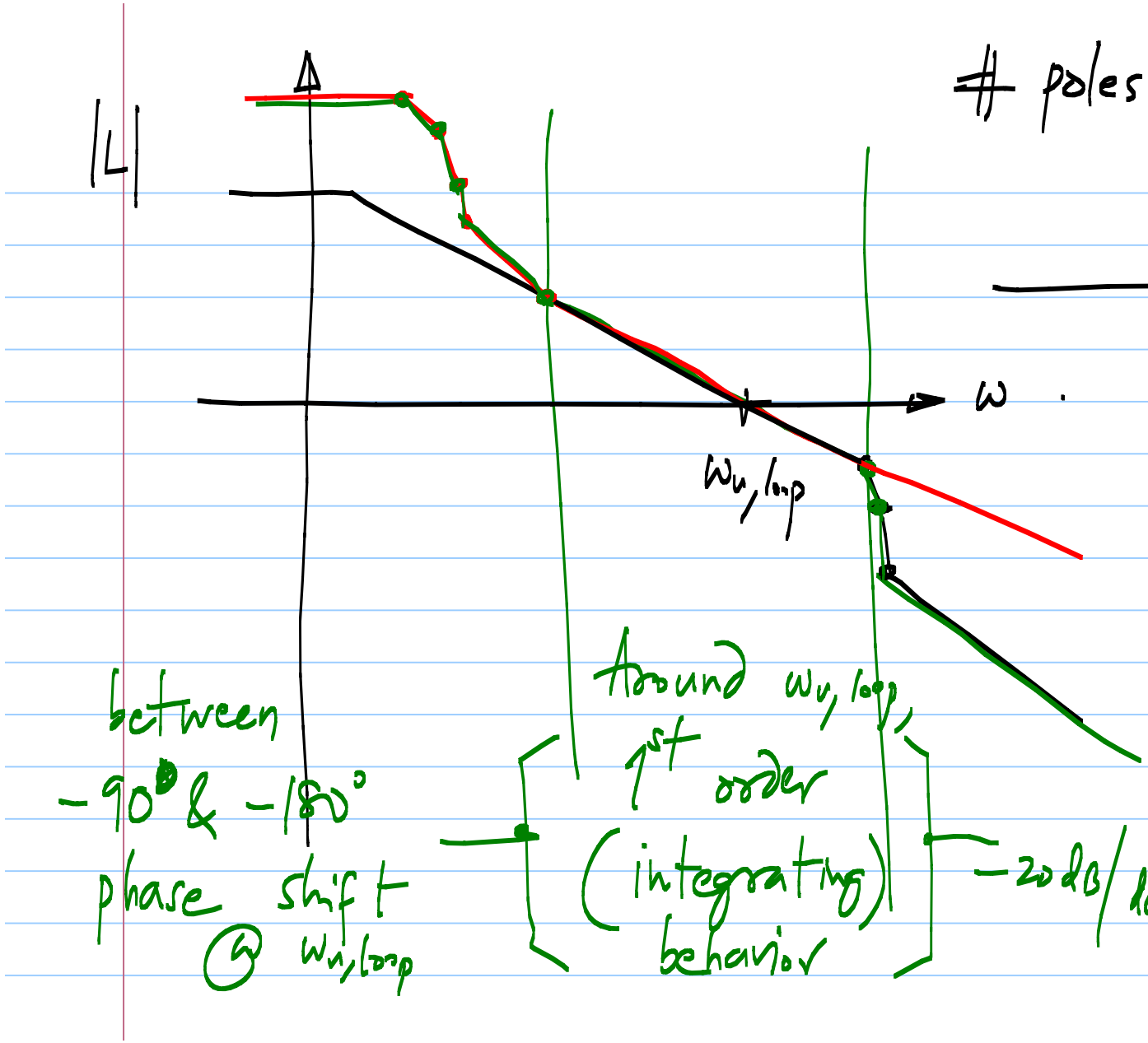
does not mean instability

Phase shift at unity loop gain magnitude ($\omega_{u,loop}$) must be between $-90°$ & $-180°$.

$\Rightarrow$ #poles − #zeros | = 1

before $\omega_{u,loop}$

1st order (integrator) behavior around $\omega_{u,loop}$]



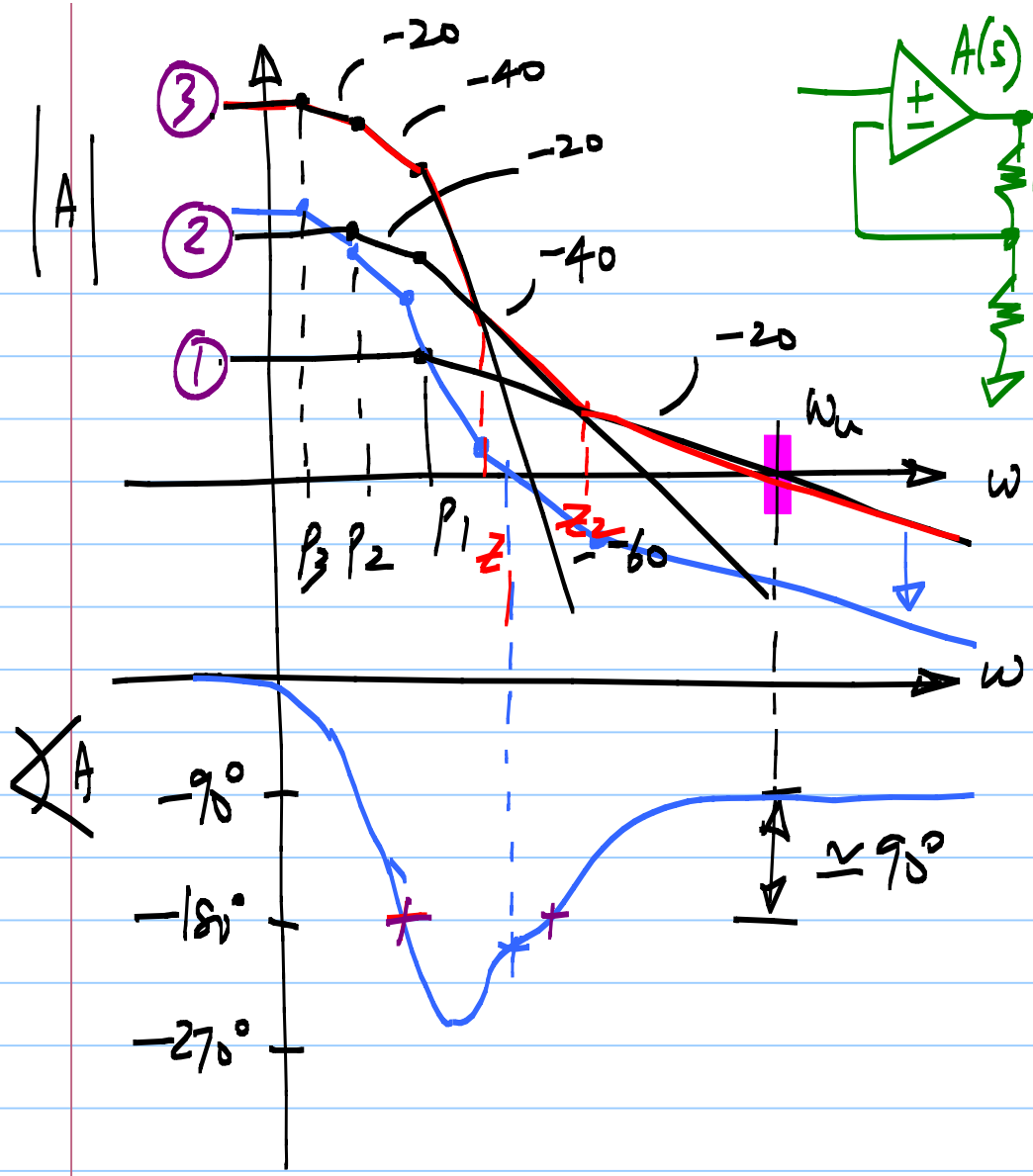
poles − # zeros | below $\omega_{u,loop}$ = −1

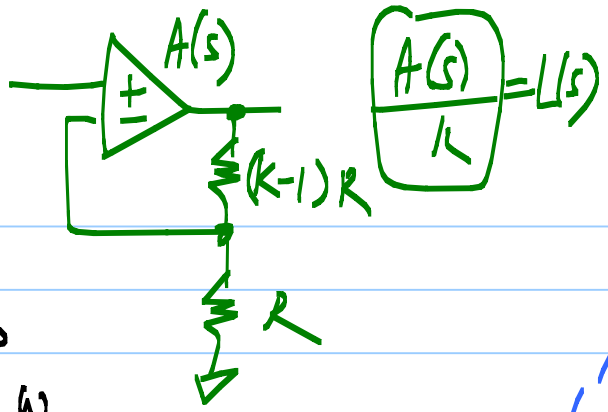
Can have poles & zeros beyond $\omega_{u,loop}$

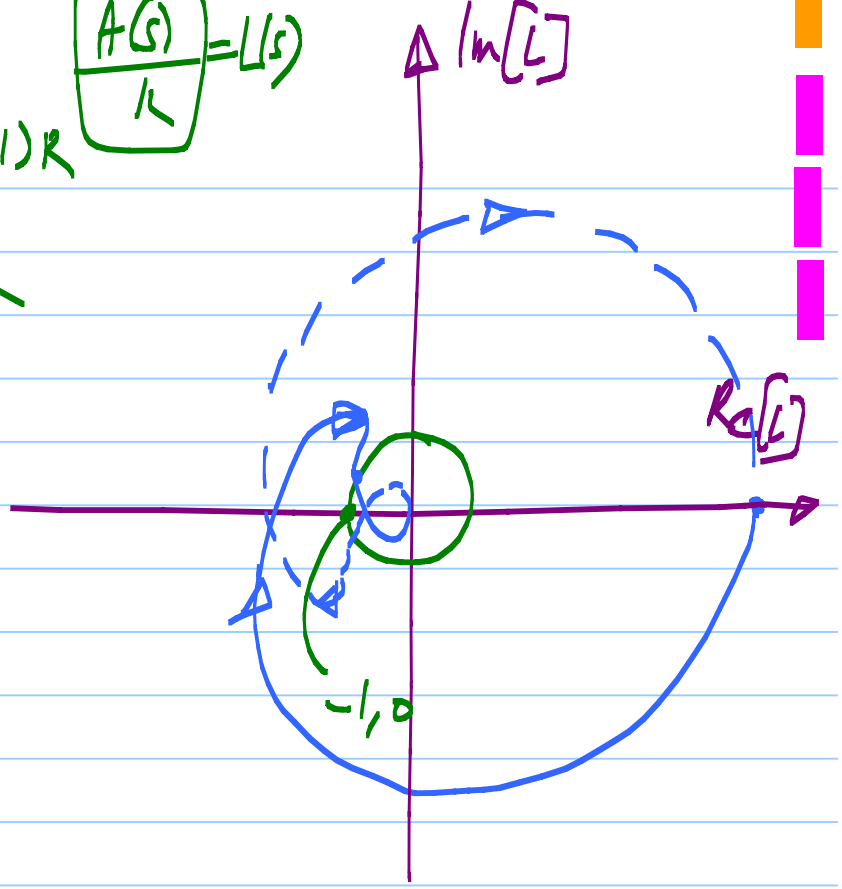
between −90° & −180° phase shift @ $\omega_{u,loop}$

Around $\omega_{u,loop}$, 1st order (integrating) behavior

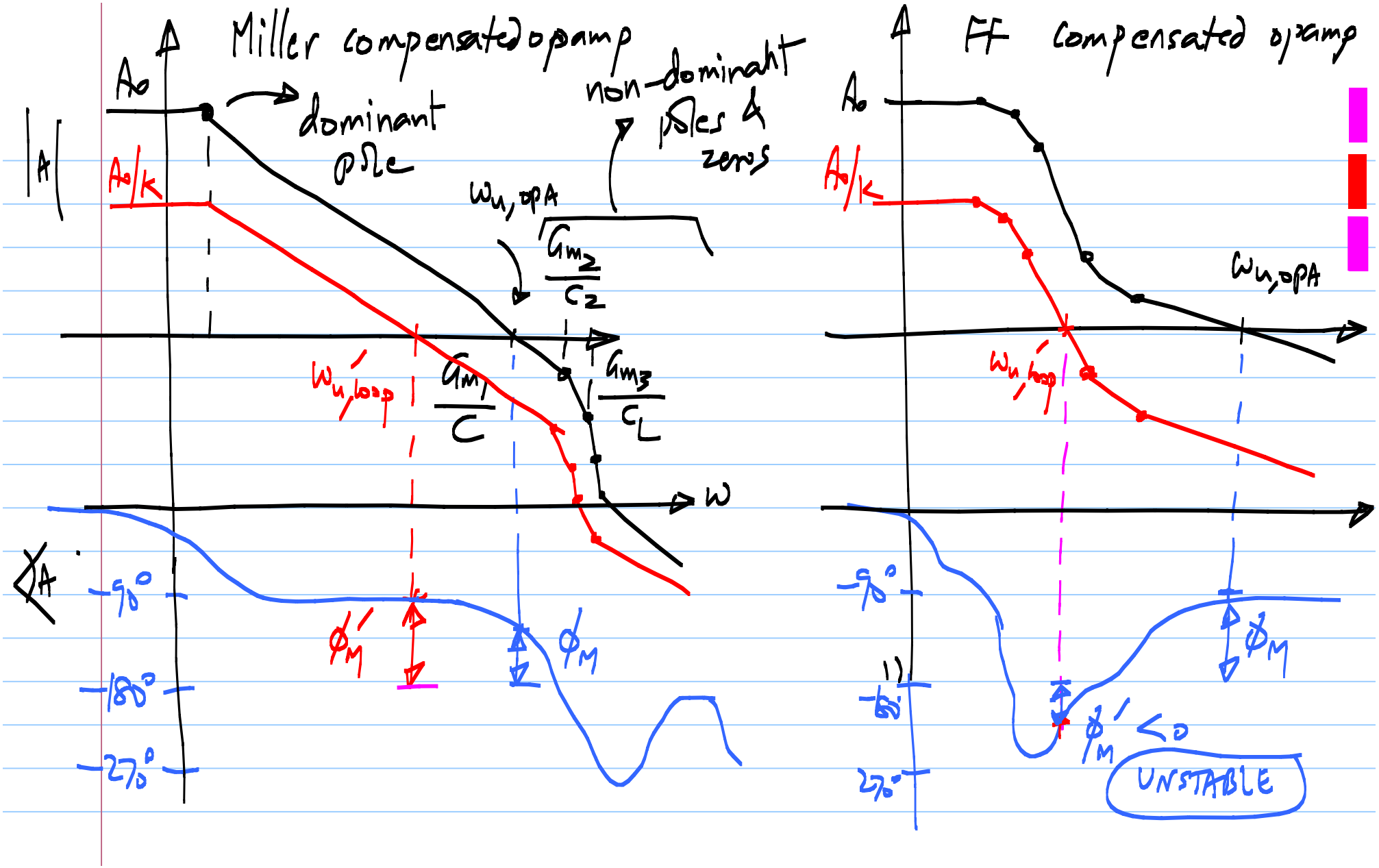
−20dB/dec. slope (Bode plot)



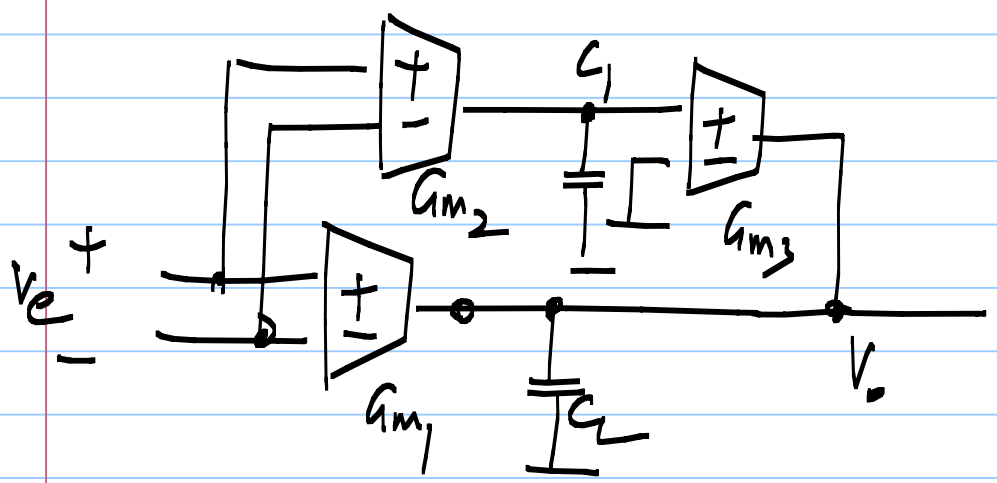


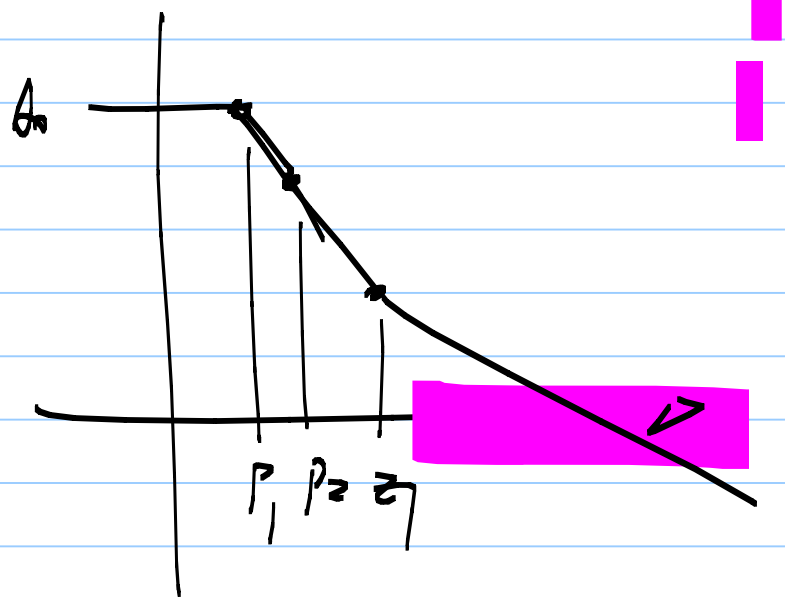


No clockwise encirclement of (-1,0) → Stable!


Miller compensated opamp
A_0
$|A|$
A_0/k
dominant pole
non-dominant poles & zeros
$\omega_{u,opA}$
$\frac{G_{m2}}{C_2}$
$\frac{G_{m3}}{C_L}$
$\omega_{u,loop}$
$\frac{G_{m1}}{C}$
ω
$\angle A$
-90°
-180°
-270°
ϕ_M'
ϕ_M
FF compensated opamp
A_0
A_0/k
$\omega_{u,opA}$
$\omega_{u,loop}$
-90°
-180°
-270°
ϕ_M
$\phi_M' < 0$
UNSTABLE

2 stage feedforward compesated opamp





$$\frac{V_o}{V_e} = \frac{G_{m_1} + \frac{G_{m_2}}{sC_1} \cdot G_{m_3}}{sC_L}$$

$$= \frac{G_{m_1}}{sC_L}\left(1 + \frac{G_{m_2} G_{m_3}}{G_{m_1} \cdot sC_1}\right) = \frac{\omega_u}{s}\left(1 + \frac{z_1}{s}\right)$$