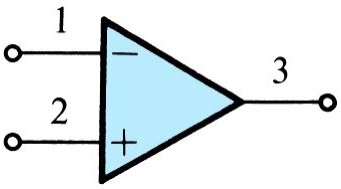
ECE 342 Electronics I

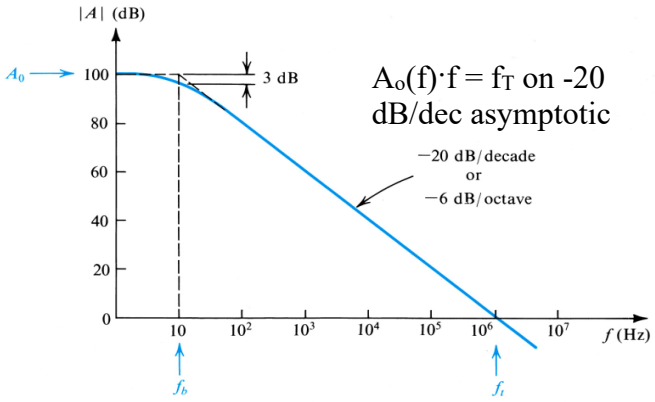
Exam I Formula Sheet **Sept. 26, 2025**

Open loop op-amp characteristics:



$v_{out} = A_o(v_+ - v_-)$, where A_o is the frequency dependent open loop gain

$f_T = A_o f_B$ is the unity gain frequency



$A_o(f)\cdot f = f_T$ on -20 dB/dec asymptotic

Closed loop op-amp characteristics, for open loop gain >> closed loop gain:

	Ideal voltage gain	Ideal input resistance
Inverting op-amp circuit	$G_v = -\frac{R_2}{R_1}$	$R_{in} = R_1$
Non-inverting op-amp circuit	$G_v = 1 + \frac{R_2}{R_1}$	$R_{in} = \infty$

Finite A_o reduces closed loop gain by a factor of $\dfrac{1 + \frac{R_2}{R_1}}{1 + \frac{1 + \frac{R_2}{R_1}}{A}}$

Maximum 3 dB frequency for both types: $f_{3dBmax} = \dfrac{f_T}{1 + \frac{R_2}{R_1}}$

General expression for inverting op-amp circuit: $V_{OUT} = -\frac{R_2}{R_1}(V_{IN} - V_{REF}) + V_{REF}$

General expression for non-inverting op-amp circuit: $V_{OUT} = \left(1 + \frac{R_2}{R_1}\right)(V_{IN} - V_{REF}) + V_{REF}$

Difference amplifiers:

Output voltage $$v_{out} = \frac{R_4}{R_3 + R_4}\frac{R_1 + R_2}{R_1}v_{i2} - \frac{R_2}{R_1}v_{i1} = A_d v_{id} + A_{cm} v_{icm}$$

Differential gain $$A_d = \frac{R_2}{R_1}$$

Common mode gain $$A_{cm} = \frac{R_4}{R_3 + R_4}\left(1 - \frac{R_2}{R_1}\frac{R_3}{R_4}\right)$$

Common mode rejection ratio $$CMRR = 20log_{10}\left(\left|\frac{A_d}{A_{cm}}\right|\right)$$

Differential input resistance $$R_{id} = 2R_1$$

Difference signal $$v_{id} = v_{i2} - v_{i1}$$

Common mode signal $$v_{icm} = \frac{1}{2}(v_{i1} + v_{i2})$$