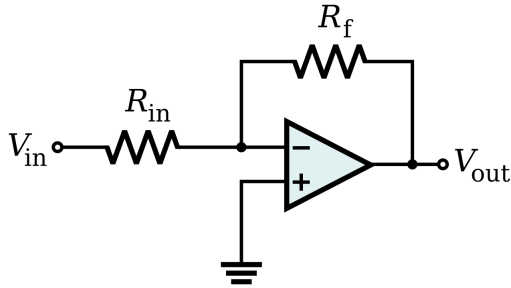
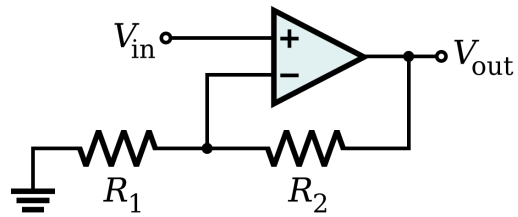


### NX-422 Exercise 3, Implantable Electronics

1. Calculate the gains of inverting and non-inverting amplifiers with resistive feedback shown below. Assume the OTAs have a large  $g_m$ .



(a) Inverting

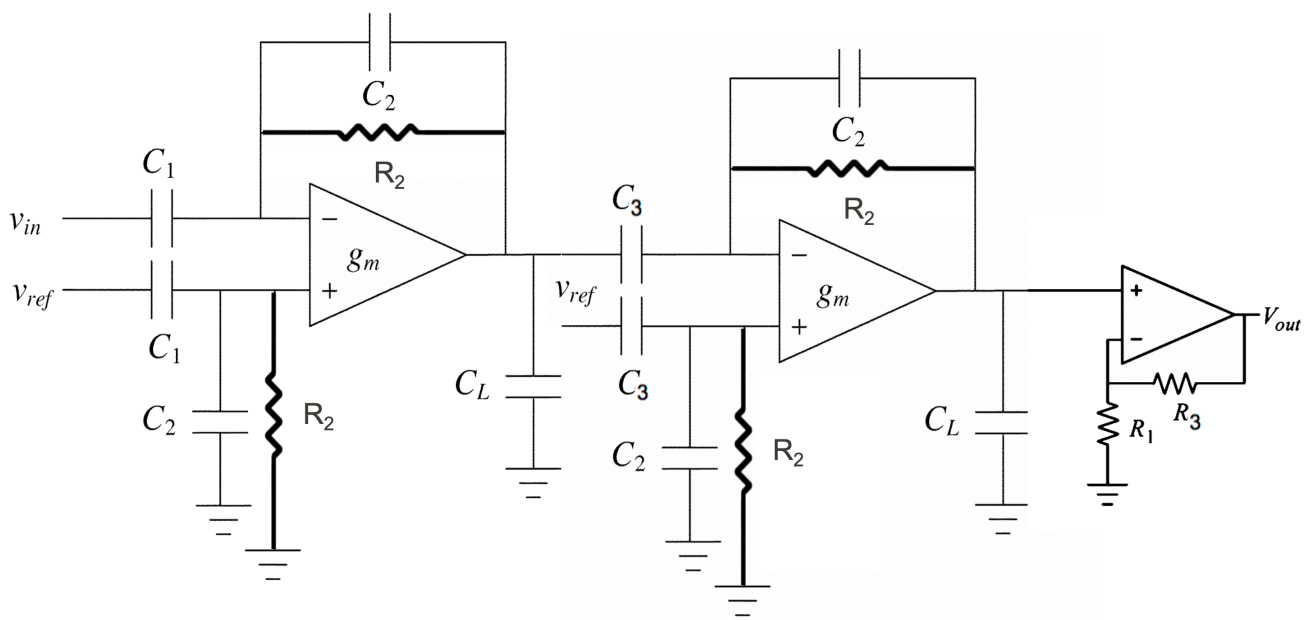


(b) Non-inverting

2. (a) For the three-stage neural amplifier shown below, find the equation for the overall mid-band gain.

(b) Assuming  $C_2 = C_u$  (unit capacitor), what are the values of  $C_1$  and  $C_3$  in terms of  $C_u$  that would result in a total mid-band gain of 1000 while minimizing the total capacitor in the circuit (and thus, the chip area)? You can ignore  $C_L$  in your calculations. Assume  $R_1=40k\Omega$  and  $R_3 = 60k\Omega$ .

(c) If the amplifier's bandwidth is set by the first stage and  $C_2 = 400\text{fF}$ , what is the value of  $R_2$  to pass signals in the LFP band (1-300Hz)?



3. Plot the drain current ( $I_D$ ) of an NMOS as a function of  $V_{GS}$  as  $V_{GS}$  varies from 0 to 3V for the following cases:

(a) Assume  $W/L = 50/0.5$ ,  $V_{DS} = 3V$ ,  $V_{TH} = 0.7V$ , and  $\mu_n C_{ox} = 50\mu A/V^2$ . What is the region of operation for the transistor?

(b) Assume  $W/L = 50/0.5$ ,  $V_{TH} = 0.7V$ , and  $\mu_n C_{ox} = 50\mu A/V^2$ . What is the region of operation if  $V_{DS} = 1V$ ? How does the equation for the current ( $I_D$ ) change in this case?