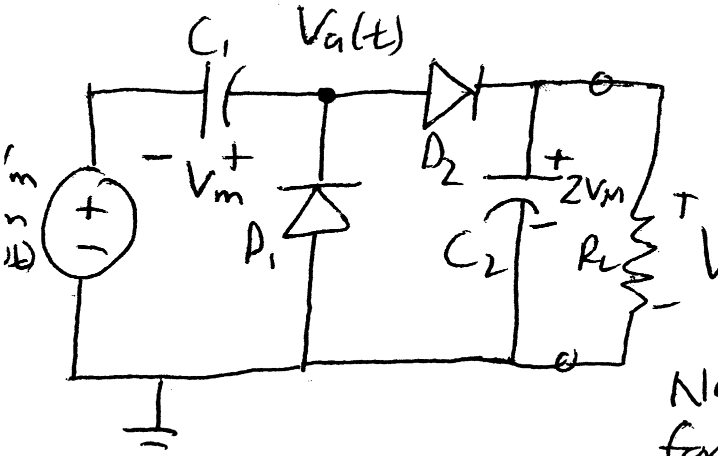
EECS 245 HMWK 3 Solution

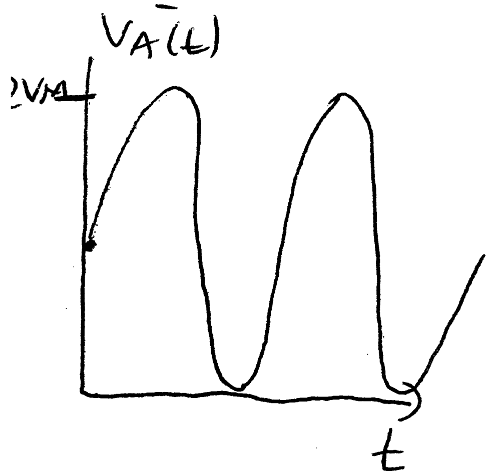
3.32, 3.33
2.14, 2.22
2.23

3.32



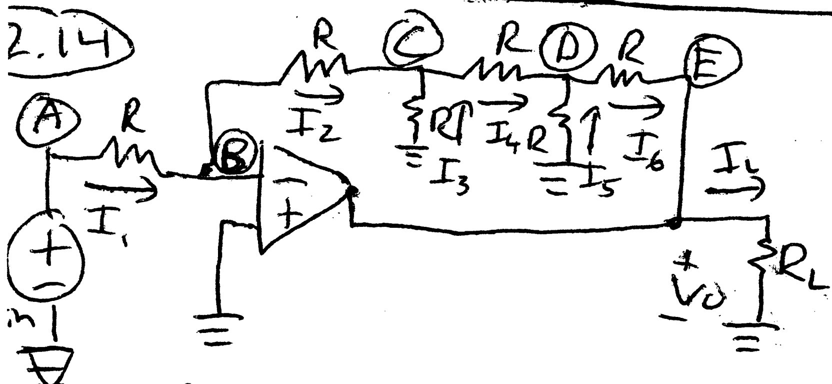
First, notice that $D_1 + C_1$ form a "clamp" circuit; i.e. when $V_m \sin(\omega t) < 0$, D_1 conducts charging C_1. Thus, negative peaks are clamped to 0V.
Now, notice that $D_2 + C_2 + R_L$ form a half-wave rectifier; thus, V_L (V_{C_2}) will charge to the peak voltage seen at $V_a(t)$. Combining the two, $V_a(t)$ will be:
$V_a(t) = V_m + V_m \sin(\omega t)$ to clamp negative peaks at 0V. Positive peaks of $V_a(t)$ will thus be at $2V_M$, which is what V_L will be.

$$V_O = V_L = V_{C_2} = 2V_M$$



Peak inverse $D_2 = 2V_m$ Peak inverse $D_1 = 2V_M$

2.14



Refer to labeled diagram.
$V_B = 0$ since $V_p = V_n$ for OP-Amp

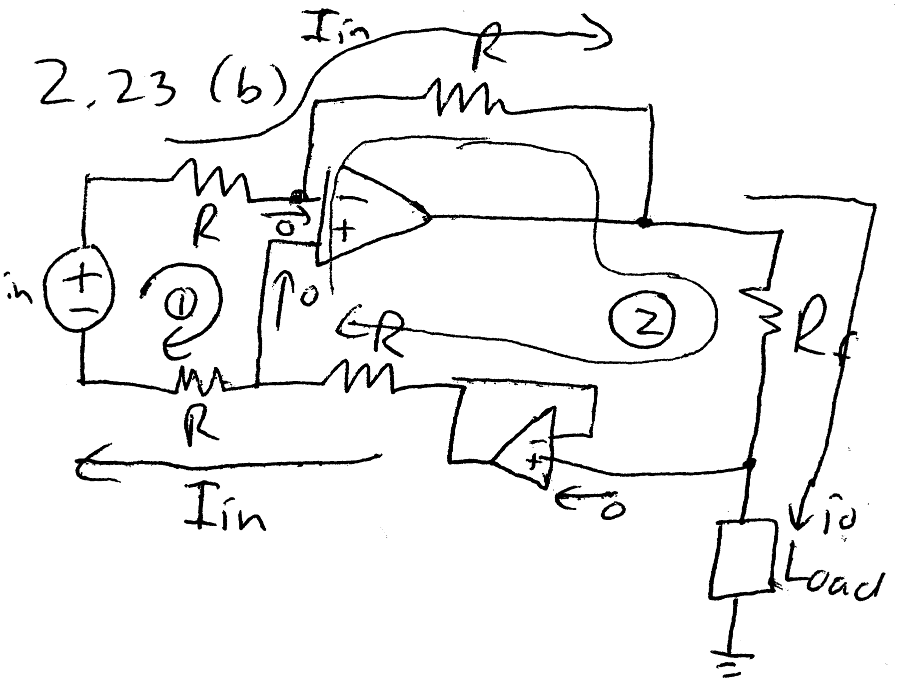
$$I_1 = \frac{A-B}{R} = \frac{V_{in}}{R} = I_1$$

$I_1 = I_2$ since $I_n = 0$

$$I_2 = \frac{B-C}{R} = \frac{V_{in}}{R} \therefore C = -V_{in} \quad I_3 = \frac{0-C}{R} \therefore I_3 = \frac{V_{in}}{R}$$

$$I_4 = I_3 + I_2 = \frac{2V_{in}}{R} \quad I_4 = \frac{C-D}{R} = \frac{2V_{in}}{R} \quad D = -3V_{in}$$

2.23 (b)



First, because $i_n = i_p = 0$, i_{in} + i_{out} must flow as shown on the diagram. Once we know this, we can apply KVL around 2 loops to get the relationship.

Loop 1: $V_{in} = I_{in}R + 0 + I_{in}R$ $\quad \underline{V_{in} = 2I_{in}R}$

Loop 2: $RI_{in} + R_f I_o + RI_{in} = 0$ $\quad \underline{2I_{in}R = -R_f I_o}$

Solving, $\boxed{i_o = -V_{in}/R_f}$ Since i_o is independent of load

$\boxed{\text{Output impedance} = \infty}$

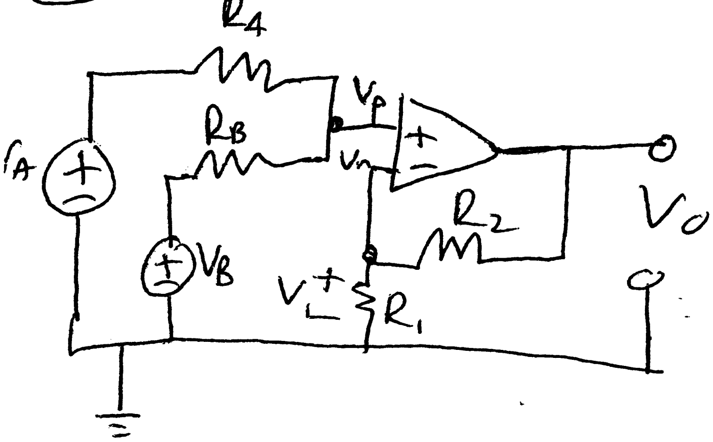
2.14 cont

$D = -3V_{in}$ $\quad I_5 = \dfrac{0-D}{R} \therefore I_5 = \dfrac{3V_{in}}{R}$

$I_6 = I_5 + I_4 \therefore I_6 = \dfrac{5V_{in}}{R}$ $\quad I_6 = \dfrac{D-E}{R}$ $\quad E = -8V_{in}$

$E = V_o \therefore V_o = -8V_{in}$ $\quad \boxed{V_o/V_{in} = -8}$

2.22



$V_n = V_p = V_1$. Now, ip must be 0 since this is the input of an OP-AMP $\therefore$

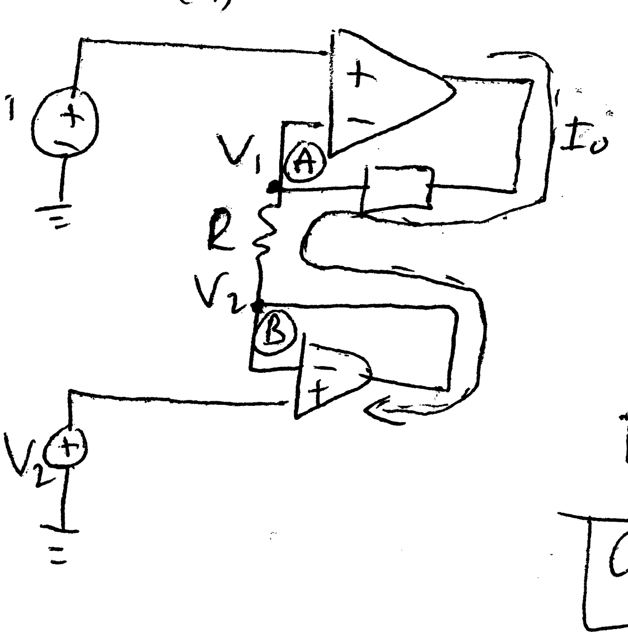
$$\frac{V_A - V_1}{R_A} + \frac{V_1 - V_B}{R_B} = 0 \text{ solving,}$$

$$V_1 = \frac{V_A R_B + V_B R_A}{R_A + R_B}$$

Now, rest of the circuit is a standard non-inverting amplifier:

$$V_o = \frac{R_1 + R_2}{R_1} V_1 \therefore \boxed{V_o = \left(\frac{R_1+R_2}{R_1}\right)\left(\frac{V_A R_B + V_B R_A}{R_A + R_B}\right)}$$

2.23 (a)



$V_p = V_n \therefore V_A = V_1$ & $V_B = V_2$

Since $i_n = 0$ for both OP-Amps, i_o must travel as shown.

$$i_o = \frac{V_A - V_B}{R} \therefore \boxed{i_o = \frac{V_1 - V_2}{R}}$$

i_o is independent of load $\therefore$

$\boxed{\text{Output impedence} = \infty}$