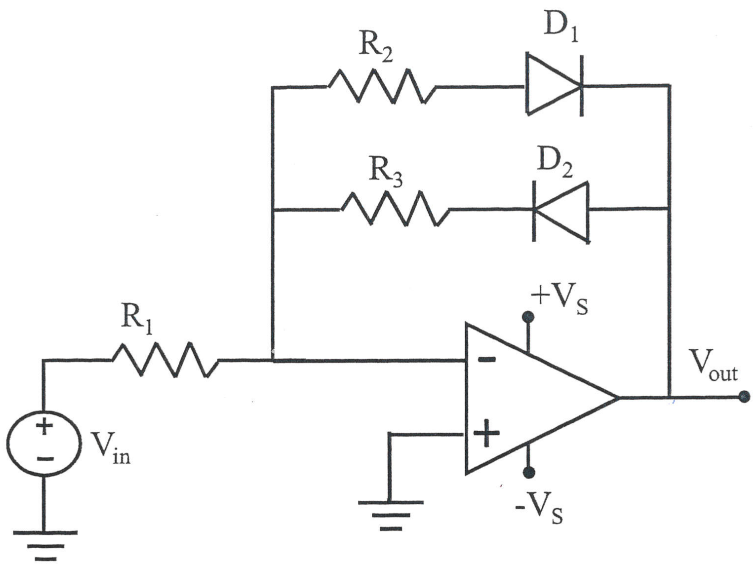
1. (25 points)

a. (10 points)



You are given the OPAMP circuit on the left with two diodes. Plot V_{out}/V_{in} by assuming OPAMP always operates in the linear region without going into saturation. The diodes are ideal with 0V turn on potential. Explain the circuit operation as much as possible. Verify the states of the diodes whenever you make assumptions.

$\frac{V_{in}-0}{R_1} + \frac{V_{out}-0}{R_{2,3}} = 0 \Rightarrow \frac{V_{out}}{V_{in}} = -\frac{R_{2,3}}{R_1}$, inverting amplifier. 02

explaining the ckt. operation.

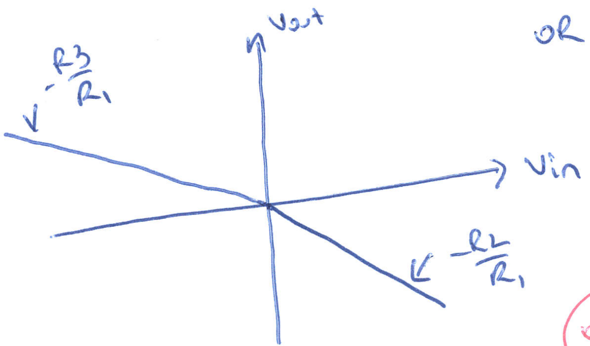
05

D_1 turns ON when $V_{out} < 0$, $V_{in} > 0$, D2 off

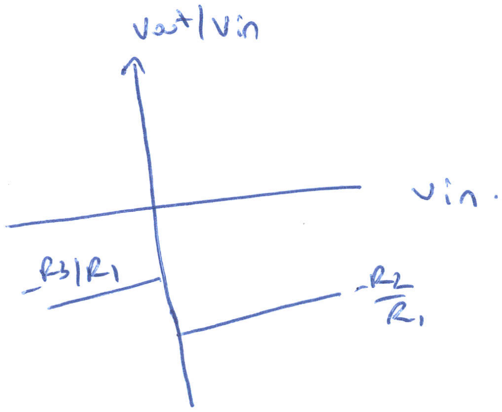
D_2 turns ON when $V_{out} > 0$, $V_{in} < 0$, D1 off

So when $V_{in} > 0$ $\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$

$V_{in} < 0$ $\frac{V_{out}}{V_{in}} = -\frac{R_3}{R_1}$



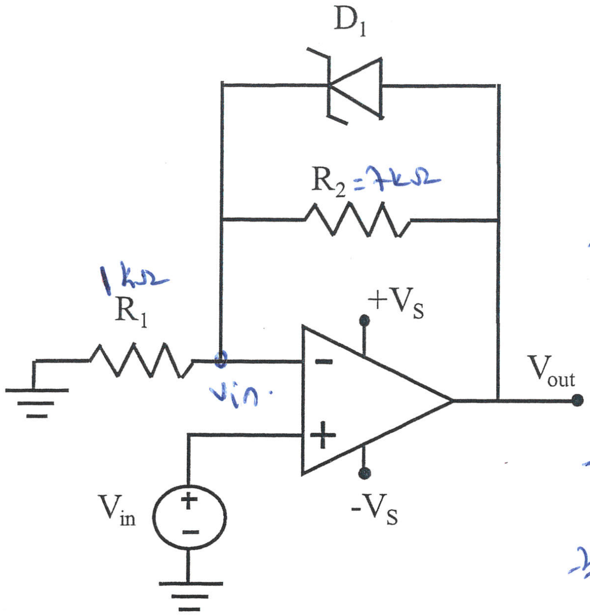
OR

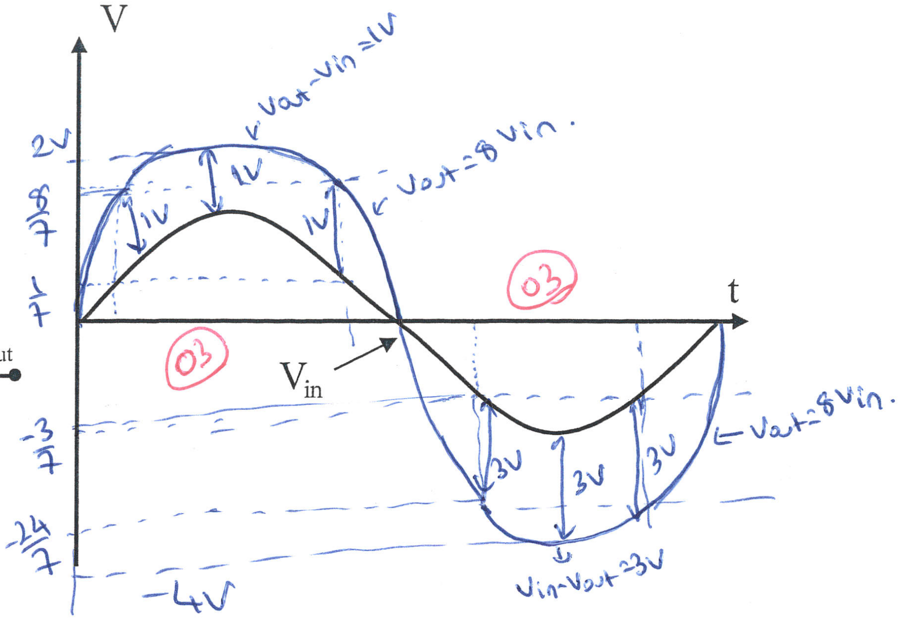


03

Student ID:

b. (15 points)





The OPAMP circuit is modified with a Zener diode for this part of the question. $V_{in}=1\sin\omega t$ V, $R_1=1k\Omega$, $R_2=7k\Omega$, and the Zener voltage is 3V in reverse bias and $V_{on}=1V$ in forward bias for the Zener diode. By assuming ideal and linear OPAMP operation without saturation, find and plot $V_{out}(t)$ for one period on the provided graph. $V_{in}(t)$ is plotted for reference. Clearly label all the critical voltage values and explain the reasoning behind your answer.

w/o zener

$V_+ = V_- = V_{in}$, $\frac{V_{in}}{R_1} + \frac{V_{in}-V_{out}}{R_2} = 0$ 03 non-inverting amplifier.

$V_{in}\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = \frac{V_{out}}{R_2}$ ⇒ $V_{in}\left(\frac{R_1+R_2}{R_1R_2}\right) = \frac{V_{out}}{R_2}$, $\frac{V_{out}}{V_{in}} = 1+\frac{R_2}{R_1} = 8$

~~when~~ The + cycle of Vin, when $V_{out}-V_{in}<1V$ regular $V_{out}=8V_{in}$.

03 when $V_{out}-V_{in}=1V$ zener turns on forward bias and $\boxed{V_{out}-V_{in}=1V}$

$7V_{in}=1V$ $V_{in}=\frac{1}{7}V$ $V_{out}=\frac{8}{7}V$ Vout follows Vin with 1V increase.

The − cycle of vin: regular $V_{out}=8V_{in}$.

when $V_{in}-V_{out}<3V$

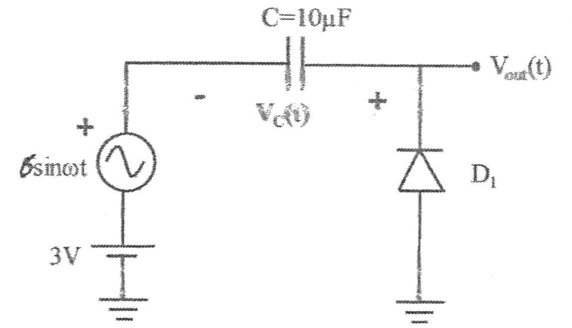
03 when $V_{in}-V_{out}=3V$ zener turns on reverse bias and $V_{in}-V_{out}=3V$ Vout follows Vin with 3V decrease.

$-7V_{in}=3V$

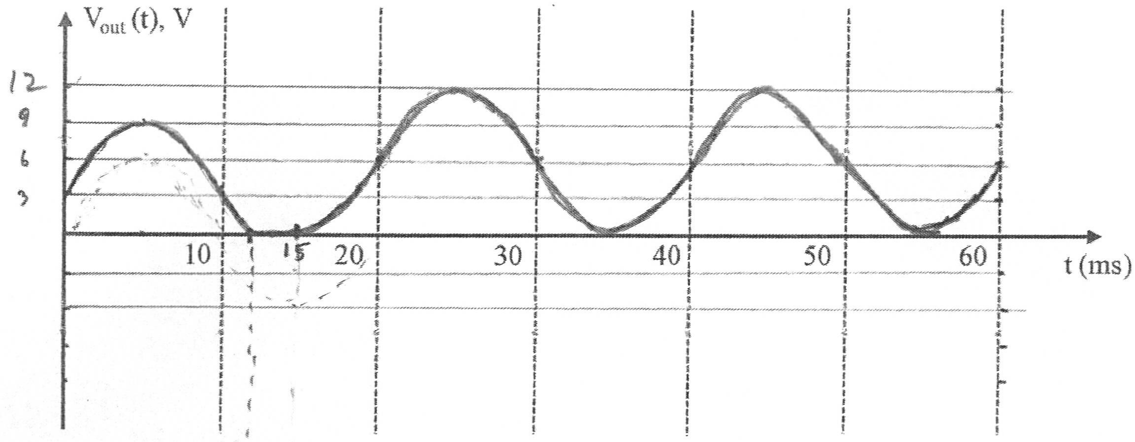
$V_{in}=-\frac{3}{7}$ $V_{out}=-\frac{24}{7}V$

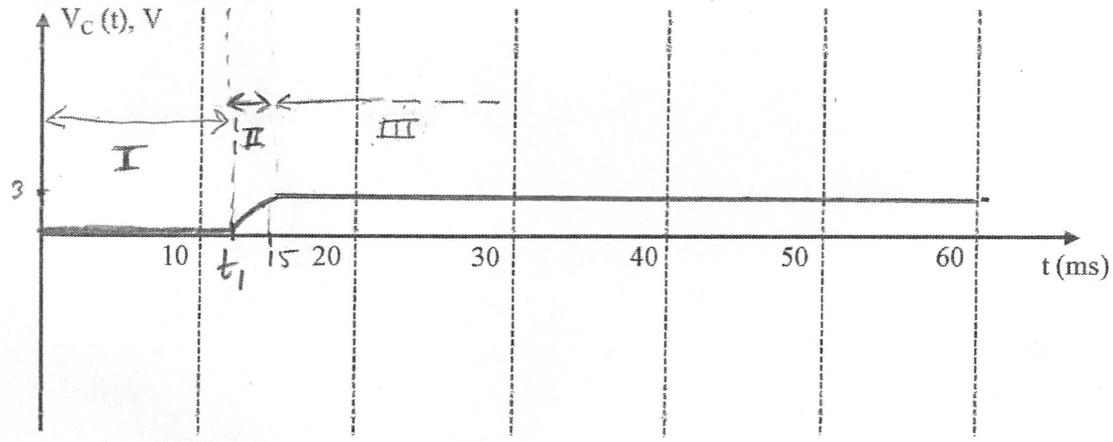
Student ID:

2. (15 points)



You are given the clamper circuit shown on the left. Find and plot $V_{out}(t)$ and $V_C(t)$ for $0<t<60$ms by assuming the diode is ideal and $\omega=2\pi f$, f=50Hz. The graphs are provided below. The capacitor voltage at t=0 is 0V, $V_C(0)=0$ V.





$6\sin\omega t = 3$

$\sin\omega t = \frac{3}{6} = 0.5$

$\omega t = 0.5236$

$t = \frac{0.5236}{2\pi \times 50} = 0.0017\,s = 1.7\,ms$ $\quad t_1 = 11.7$ msec

phase I : 3p

phase II : 2p

phase III : 8p

t_1 : 2p

Student ID:

$\omega t = 30°$

$t = \frac{30°}{360° \times 50} = 0.0017$