1. Academic Honesty.

a) An permissible and honest work means that one finish the work by their own. without copying from others or other not-permitted resources. For colaboration work. careful clarify how partners colaborate in the project and cite every related resource that helped.

b) Copying from others, colaborating an assignment without permission. use of views or opinions from others without acknowledgement

2. Island Karaoke Machine.

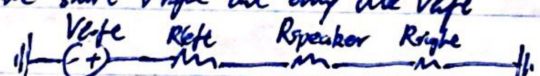
$R_{left} = R_{right} = 3\Omega$. $R_{speaker} = 4\Omega$

$V_{left} = V_{vocals}$. $V_{right} = V_{vocals} + V_{instrument}$. $V_{vocal} = 120.524\,mV$. $V_{instrument} = 50\,mV$

a) Since. $V_{right} = V_{left} + V_{instrument}$. $|V_{right}| > |V_{left}|$

Use superposition: ① when we short V_{right} and only use V_{left}

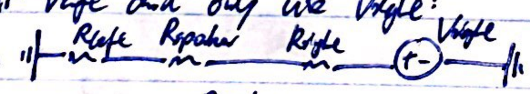
The circuit:



Thus $V_{speaker,1} = V_{left} \times \frac{R_{speaker}}{\Sigma R} = V_{vocal} \times \frac{4\Omega}{3\Omega\times2+4\Omega} = 0.4\,V_{vocals}$

② When we short V_{left} and only use V_{right}:

The circuit:



Thus $V_{speaker,2} = V_{right} \times \frac{R_{speaker}}{\Sigma R} = (V_{vocals} + V_{instrument}) \times \frac{4\Omega}{10\Omega} = 0.4(V_{vocals} + V_{instrument})$

since $|V_{right}| > |V_{left}|$, we see the current as from V_{right} to V_{left}.

Thus $V_{speaker} = V_{speaker,2} - V_{speaker,1} = 0.4 \times V_{instrument} = \underline{20\,mV}$

$\Downarrow$

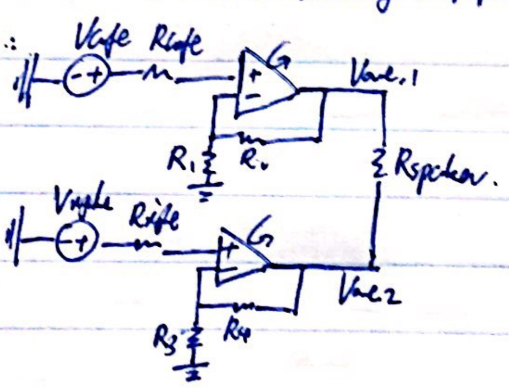
Not depend on V_{vocals}.

Hear Instrument only

b) $P_{speaker} = V_{speaker} I_{speaker} = \frac{V_{speaker}^2}{R_{speaker}} = \frac{(20mV)^2}{4\Omega} = \frac{400}{4} \times 10^{-6} W = 1 \times 10^{-4} W$

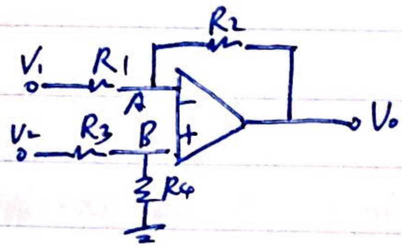
c) As discussed in part a). we know that $V_{speaker} = V_{speaker,2} - V_{speaker,1}$
If we use amplifiers. then it's same that we amplify $V_{speaker,1}$. thus it equals that
$V_{speaker} = 100 \times (-1)^i \times 0.4 (V_{vocal} + V_{instrument}) - 100(-1)^j (V_{vocal}) \times 0.4$
$= 40 V_{vocals} ((-1)^i - (-1)^j) + 40 \times (-1)^i V_{instrument}$
Since we don't need V_{vocals}. then $(-1)^i - (-1)^j = 0$ thus $i = j$ thus the two amplifiers must be the same kind. and since $i = 0$ or 1 and here in order to make $(-1)^i$ be positive. we use $i = j = 0$, which means non-inverting amplifiers.
thus ~~$V_{speaker} = 100 \times V_{speaker,original} = 2000mV = 2V$~~
Difference $= 100 \times (V_{right} - V_{left}) = 100 \times V_{instrument}$ ~~$(40 V_{instrument} \times 0.4)$~~

d) $P_{speaker} = 1W = 10^4 \times P_{speaker,original} = 10^4 \times \frac{V_{speaker,original}^2}{R_{speaker}}$
thus $V_{speaker,new} = 10^2 \times V_{original} = 100 \times 20mV = 2V$.
As stated in c). we use both non-inverting amplifier.
Then the circuit:



thus $|V_{out,1} - V_{out,2}| = 2V$
$= G(V_{right} - V_{left})$
$= G \cdot V_{instrument}$
$= G \times 50 \times 10^{-3} V$
$\Rightarrow G = 40$

And since $V_{out} = (1 + \frac{R_2}{R_1}) V_{in}$ for non-inverting amplifier, $1 + \frac{R_2}{R_1} = 40 \Rightarrow R_2 = 39 R_1$
thus. $R_4 = 39 R_3$ and $R_2 = 39 R_1$

e) 

label node A & B in circuit

then when $V_2=0$ $V_B=0=V_+=V_-$ (Golden Rule) $=V_A$

Thus analyze node A: $(-\frac{V_A-V_1}{R_1}) = \frac{V_A-V_o}{R_2} \Rightarrow \frac{-V_1}{R_1} = \frac{V_o}{R_2}$, then $V_o = -\frac{R_2}{R_1}V_1$

f) when $V_1=0$. thus. $V_+=\frac{R_4}{R_3+R_4}\times V_2 = V_- = V_A$

when we analyze A node: $\frac{V_A-0}{R_1}+\frac{V_A-V_o}{R_2}=0 \Rightarrow \frac{V_A}{R_1}+\frac{V_A}{R_2}=\frac{V_o}{R_2}$

thus $V_o=\frac{R_2}{R_1}V_A+V_A=V_A(1+\frac{R_2}{R_1})=\frac{R_4}{R_3+R_4}\times\frac{R_1+R_2}{R_1}\times V_2$

g) $V_o = V_{o,e)} + V_{o,f)} = \frac{R_4}{R_3+R_4}\times\frac{R_1+R_2}{R_1}\times V_2 - \frac{R_2}{R_1}V_1$.

Take V_1 as V_{left} and V_2 as V_{right}

thus $\frac{R_2}{R_1} = \frac{R_4}{R_3+R_4}\times\frac{R_1+R_2}{R_1}=40$. then $R_2=40R_1 \Rightarrow \frac{R_1+R_2}{R_1}=41 \Rightarrow \frac{R_4}{R_3+R_4}=\frac{40}{41}\Rightarrow R_4=40R_3$

Thus $V_o=40V_2-40V_1=40(V_2-V_1)$ and for example $R_1=R_3=1\Omega$ and $R_2=R_4=40\Omega$

3. Jumplue.

a) Because of the Golden Rule $V_+ = V_- = 0V$

~~Thus we get~~ $\cancel{\frac{V_- - V_0}{R_1} + C\frac{dV}{dt} = 0 \Rightarrow \frac{V_- - V_0}{R_1} = C \times C(V_- - V_1) \Rightarrow V_- = CR_1V_- - CR_1V_1 + V_0}$

Thus. $\frac{V_- - V_0}{R_1} = C_1\frac{dV}{dt} = 0 \Rightarrow \frac{V_0}{R_1} = C_1\frac{dV}{dt} \Rightarrow \frac{V_0}{R_1}dt = C_1 dV$ (integrate both sides)

$\int \frac{V_0}{R_1}dt = \int C_1 dV \Rightarrow CV = \frac{V_0}{R_1}t \Rightarrow V = \frac{V_0}{R_1}\frac{t}{C} = V_- - V_1$

$\Rightarrow V_1 = -\frac{V_0 t}{R_1 C}$

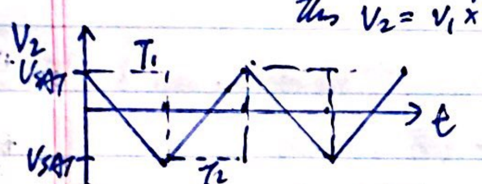
b) Since $V_1 = -\frac{V_0 t}{RC} = -\left(\frac{V_0}{RC}\right)t$

~~But by calculating area:~~ $\cancel{\frac{1}{2} \times T_1 \times (2V_{SAT}) =}$

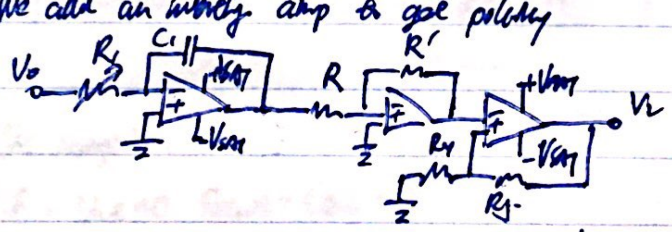
Slope $= \frac{2\times V_{SAT}}{T_1} = \frac{V_{SAT}}{R_1C_1} \Rightarrow T_1 = \frac{2V_{SAT}R_1C_1}{V_{SAT}} = T_2$

c) Since Golden Rule: $V_1 = V_- = V_+ = V_2 \times \frac{R_4}{R_4+R_5} = -\frac{V_0}{R_1C}t$

Thus $V_2 = V_1 \times \frac{R_4+R_5}{R_4}$ (slope doesn't change). thus the graph is a amplified version for V_1 graph in b)



d) We add an inverting amp to get polarity



e) Since $1/1Hz = 1s \Rightarrow 1/1kHz = 10^{-3}s$, $T = \frac{2V_{SAT}R_1C_1}{V_{SAT}} = \frac{2\times 5V \times R_1 \times 10^{-5}F}{10V} = 10^{-5}R_1 \cdot F$

Since 2T is a period thus $10^{-3} = 2\times10^{-5}R_1\cdot F \Rightarrow$ thus $R_1 = 50\Omega$

thus $V_{TH} = \frac{R_4}{R_4+R_5}V_{SAT} = 5V = \frac{10k\Omega}{10k\Omega+R_5}\times 10V \Rightarrow 20 = 10 + R_5 \Rightarrow R_5 = 10k\Omega$

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4. Rain Sensor V2.0

a) $C = \frac{\varepsilon A}{d}$. $C_{empty} = \frac{\varepsilon \cdot w \cdot h_{tot}}{w} = \varepsilon \cdot h_{tot}$

$C_{tank} = C_{empty} + C_{water} = \frac{\varepsilon \cdot w \cdot (h_{tot} - h_{H_2O})}{w} + \frac{81\varepsilon \cdot w \cdot h_{H_2O}}{w} = \varepsilon(h_{tot} - h_{H_2O}) + 81\varepsilon \cdot h_{H_2O}$

$= \varepsilon h_{tot} + 80\varepsilon h_{H_2O} = C_{empty} + 80\varepsilon h_{H_2O}$

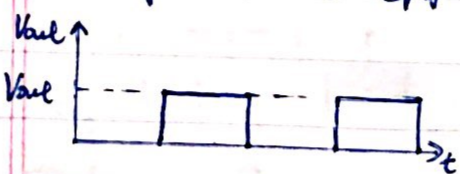
b) When ϕ_1 is on and ϕ_2 is off:

C_{in} is charged, $Q_{C_{in}} = C_{in} \cdot V_{in}$. C_f is discharged.. thus $V_{out} = V_{C_f} = 0$

When ϕ_2 is on and ϕ_1 is off:

$Q_{C_f} = -Q_{C_{in}} = -C_{in}V_{in} = -C_f V_f \Rightarrow V_{out} = V_f = \frac{C_{in}V_{in}}{C_f}$.

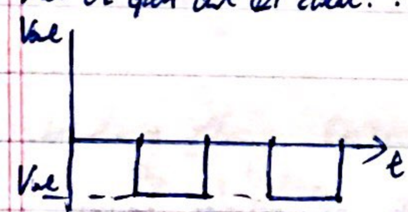
charges are transferred through amp and this voltage is produced

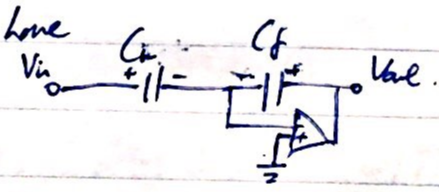


c) In ϕ_1 open and ϕ_2 close:

C_{in} is discharged. $Q_{C_f} = Q_{out} = Q_{in} = 0$. and thus $V_{out} = 0$

When ϕ_2 open and ϕ_1 closed: we have





and $C_f V_f = C_f V_{out} = C_{in} V_{in} \Rightarrow V_{out} = \frac{C_{in}V_{in}}{C_f}$

d) Use superposition

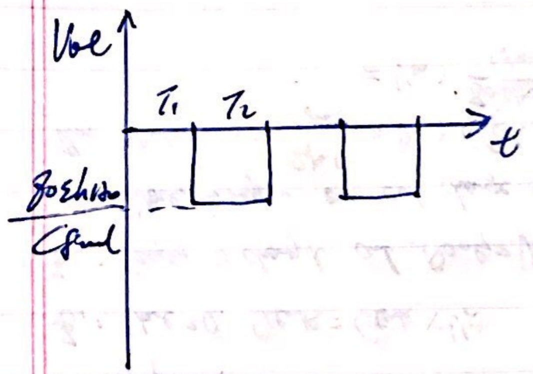
ϕ_1: $V_{out} = 0$. $Q_{tank} = C_{tank} \times V_{in}$

ϕ_2: C_{empty} is charged.. and $Q_{empty} = V_{in} \cdot C_{empty}$

Since $V_{out,2}$ is negative the total charge on $C_{final} = Q_1 - (Q_2) = C_{tank} \times V_{in} - V_{in} \times C_{empty}$.

Thus $V_{final} = V_{out} = \frac{Q_{final}}{C_{final}} = V_{in} \times (C_{tank} - C_{empty}) \times \frac{1}{C_{final}} = (C_{empty} + 80\varepsilon h_{H_2O} - C_{empty}) \times V_{in} \times \frac{1}{C_{final}}$

$= V_{in} \times \frac{80\varepsilon h_{H_2O}}{C_{final}}$

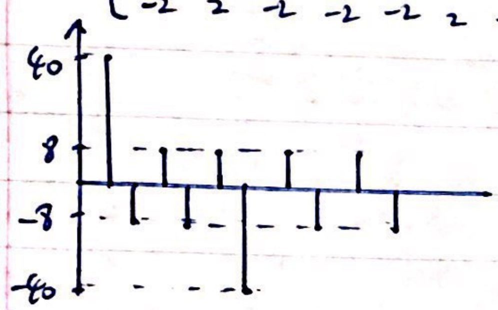


e) This problem's final formula looks simpler thus I would prefer this one since it can help avoiding too much calculation.

5. Mechanical Correlation

a) First:

$$\begin{bmatrix} 2 & -2 & 2 & -2 & -2 & -2 & 2 & -2 & 2 & 2 \\ 2 & 2 & -2 & 2 & -2 & -2 & -2 & 2 & -2 & 2 \\ 2 & 2 & 2 & -2 & 2 & -2 & -2 & -2 & 2 & -2 \\ -2 & 2 & 2 & 2 & -2 & 2 & -2 & -2 & -2 & 2 \\ 2 & -2 & 2 & 2 & 2 & -2 & 2 & -2 & -2 & -2 \\ -2 & 2 & -2 & 2 & 2 & 2 & -2 & 2 & -2 & -2 \\ -2 & -2 & 2 & -2 & 2 & 2 & 2 & -2 & 2 & -2 \\ -2 & -2 & -2 & 2 & -2 & 2 & 2 & 2 & -2 & 2 \\ 2 & -2 & -2 & -2 & 2 & -2 & 2 & 2 & 2 & -2 \\ -2 & 2 & -2 & -2 & -2 & 2 & -2 & 2 & 2 & 2 \end{bmatrix} \begin{bmatrix} 2 \\ -2 \\ 2 \\ -2 \\ -2 \\ -2 \\ 2 \\ -2 \\ 2 \\ 2 \end{bmatrix} = \begin{bmatrix} 40 \\ 40-24\times2 \\ 40-16\times2 \\ 40-14\times2 \\ 40-16\times2 \\ -40 \\ 40-16\times2 \\ 40-24\times2 \\ 40-16\times2 \\ 40-14\times2 \end{bmatrix} = \begin{bmatrix} 40 \\ -8 \\ 8 \\ -8 \\ 8 \\ -40 \\ 8 \\ -8 \\ 8 \\ -8 \end{bmatrix}$$



Second:

[Use Matlab]

b) [Use Matlab]

6. Fanberg Cheng 3033207855 / Cong Yang: 3032217722
Samuel Arredondo 23804677
We rarely really meet but we communicate if we have problems with concepts or methods.

⇒ I, Wayne Li, affirm that all of my solutions are entirely my work and that I have properly credited and acknowledged any sources or work that I have consulted.

```
function [result,result_b] = part_a_second()
  close all
  x = [0 1 2 3 4 5 6 7 8 9];
  y = [1 2 3 4 5 6 7 6 5 4];
  the_y = zeros(10,10);
  the_y(1,:) = y;
  for i = 2:10
    index = i - 1;
    the_y(i,:) = [y(i:end), y(1:index)];
  end
  result = the_y * y';
  figure(1);
  plot (x,result);
  y_of_first = [2 -2 2 -2 -2 -2 2 -2 2 2];
  figure(2);
  result_b = the_y * y_of_first';
  plot(x, result_b);
end
```