# Assignment-1

## Op-Amp

1.

A valve is used to release (when valve is OPEN,) or maintain (when valve is CLOSED,) water pressure in a water tank. The valve operates on **ACTIVE LOW** logic. (i.e., the valve is OPENED when given a LOW voltage of 1 $V$**,** but remains CLOSED when provided a HIGH voltage of 6 $V$**.**)

A pressure sensor is installed in the water tank that outputs a voltage linearly proportional to pressure, as shown in the table below.

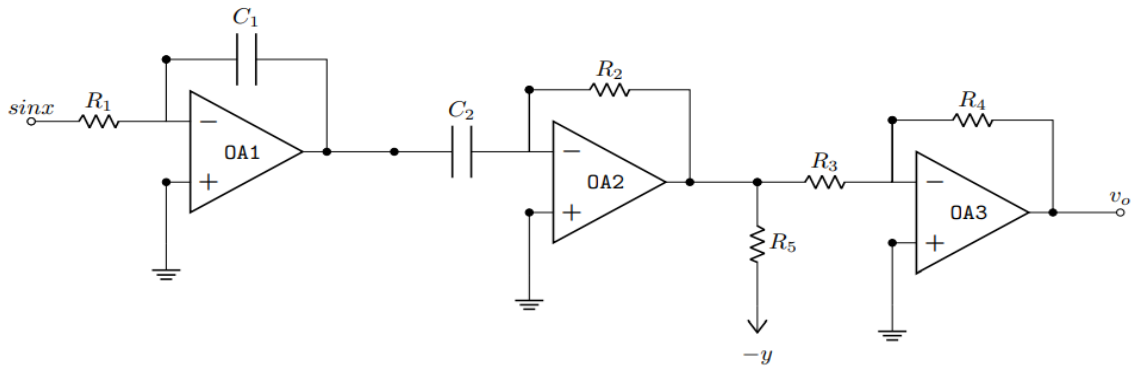
| At **0.5 atm** pressure | At **1 atm** pressure | At **1.5 atm** pressure |
|---|---|---|
| $v_{0.5\ atm} = 0.5\ V$ | $v_{1\ atm} = 3\ V$ | $v_{1.5\ atm} = 5.5\ V$ |

The pressure in the water tank can be measured by the formula $P = h\rho g$, where $P$**,** (in **Pascals (Pa)** unit) is the water pressure, $h$ is the height of water in the tank (in $metres$), ρ(= $1000\ kgm^{-3}$) is the density of water and $g$ is the acceleration due to gravity (in $ms^{-2}$).

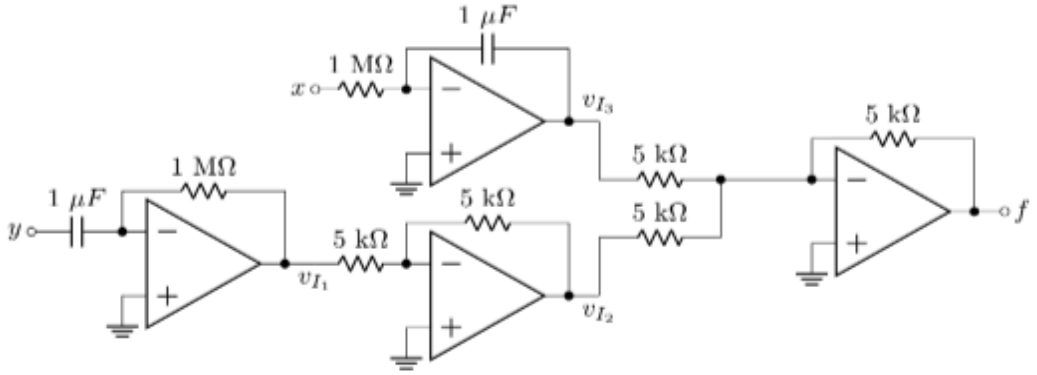
**[1 atm = 101325 Pa]**

i. **Design** a circuit using Op-Amp comparator to automatically turn OPEN the valve if water level exceeds **10 m**.
ii. **Draw** the voltage transfer characteristics (VTC) of the designed Op-Amp.

2. **Deduce** the expression for output, $\mathbf{V_o}$ from the circuit above



3.



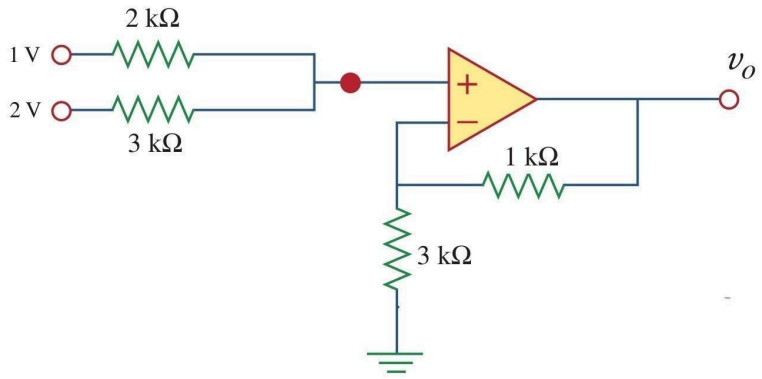

(a) **Analyze** the circuit above to find an expression of $f$ in terms of inputs $x$ and $y$. Also, **determine** the intermediate outputs $v_{I_1}$, $v_{I_2}$, and $v_{I_3}$ as denoted in the circuit. [4]

(b) Draw the circuit of an inverting amplifier and **design** it in such a way that the voltage gain, $k = -4$. (*i.e.*, find the values of $R_1$ and $R_2$). [3]

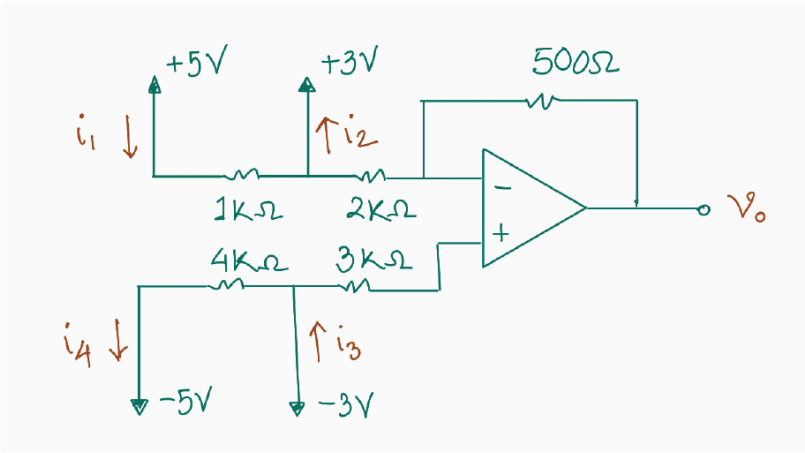
(c) **Show** the input and output waveforms of the inverting amplifier of part (b) assuming a sinusoidal input of 0.5 V amplitude. **Calculate** the amplitude of the output. [2]

(d) Consider the inverting amplifier of part (b) again. Assume the input voltage can provide a maximum current of 0.5 μA. **Determine** the design changes required, if any, for the circuit to work. [1]

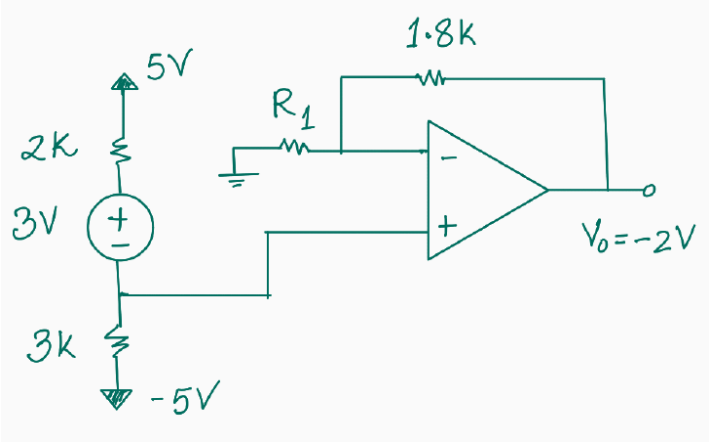
4. Consider the Ideal Op-Amp and find the value of Vo.



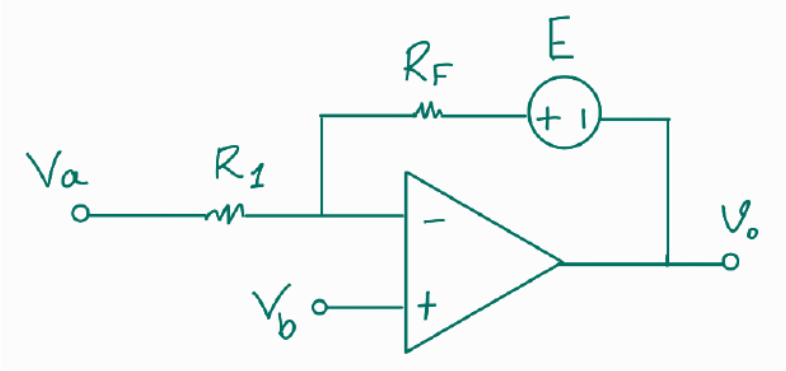
5. **Determine the marked currents and the output voltage**



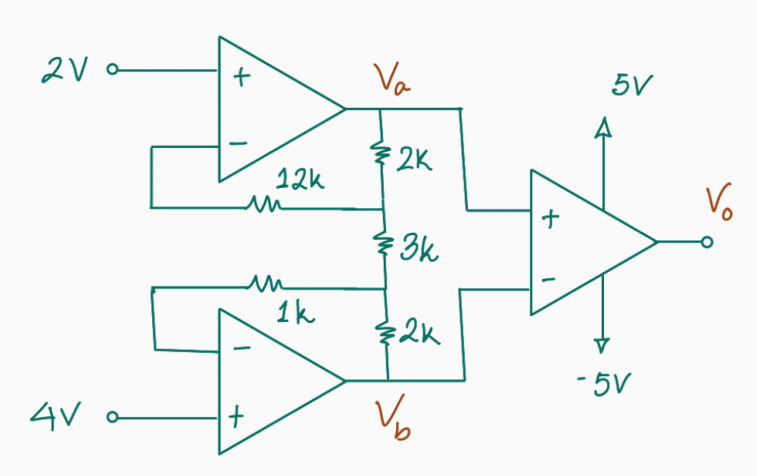

6. **Determine the appropriate value of** $R_1$



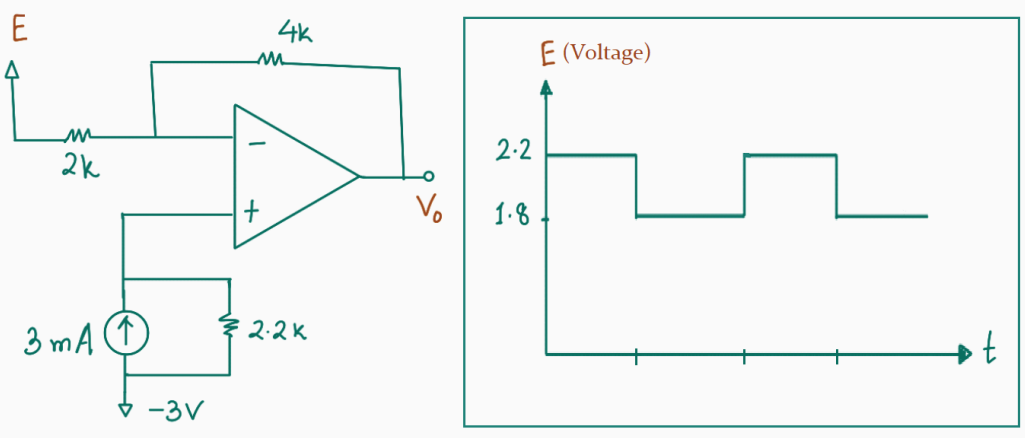

7. **Express the output voltage** $v_0$ **in terms of all the other quantities shown in the circuit below.**



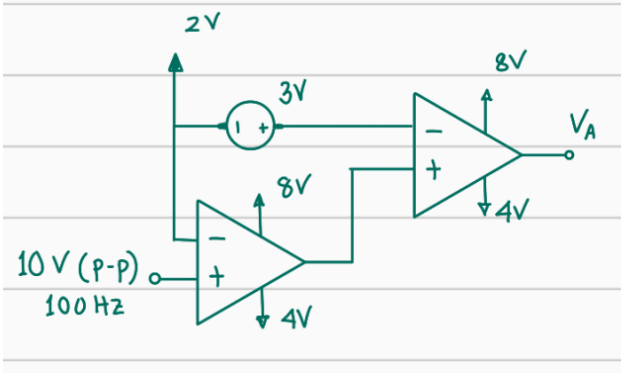
8. **Determine the output of the comparator, $V_0$ after finding $V_a$ and $V_b$.**

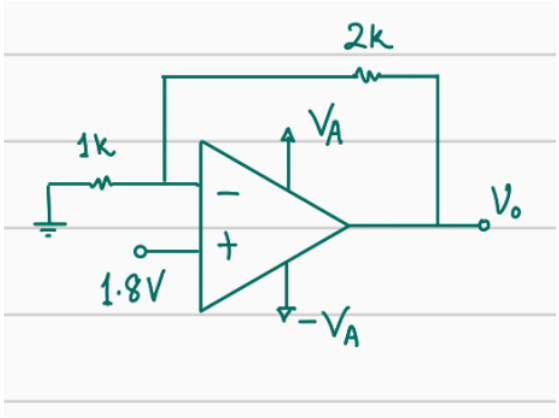



9. **Draw the correct waveform of $V_0$ (with voltage labels) alongside the input waveform of $E$.**




10. **Draw the approximate waveforms of both $V_A$ and $v_0$ from the circuit below.**




2k
1k
$V_A$
$V_o$
1.8V
$-V_A$