BRAC University
Dept. of Computer Science and Engineering

Semester:	Fall 2023
Course Code:	CSE251
Section:	**15**
Course Name:	Electronic Devices and Circuits

Assessment:	Assignment 2
Due:	**11:59 AM 17 October 2023**
Full Marks:	40

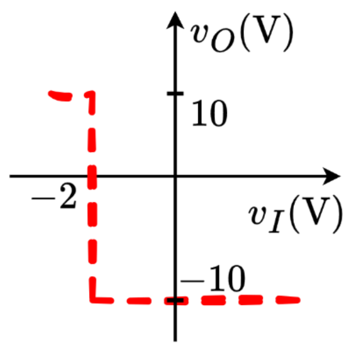
Name: ______________________________

Student ID: ______________________________

- ✓ Write down your student ID on the **top right corner of each of the pages**.
- ✓ Clearly write the solutions, along with the questions, on white paper with black ink (no need to use color pen, don't use pencils).
- ✓ Use **CamScanner**, or **Adobe Scan**, or **Microsoft Office Lens**, or any other software to scan the pages and make a **single PDF file**.
- ✓ After creating the PDF, make sure that **(a)** there are no pages missing, **(b)** all of the pages are legible, **(c)** your student ID on each page are visible.
- ✓ Please note, **collaboration ≠ copying**. You are allowed to discuss the questions and clear confusion you might have, but you have to write your solutions independently and be able to explain your answers during a random viva.
- ✓ [**Very Important**] Rename the PDF in the following format: **"A1_StudentID_FullNameWithoutSpace.pdf"**. For example, if my student ID is 12345678 and my name is Shadman Shahid, the filename should be **"A1_12345678_ShadmanShahid.pdf"**.
- ✓ **Submission Link: https://forms.gle/j81vXAmKcUwarxZy8**

[CO3] Question 1: 14 Marks

a) Design a circuit using **op-amp** that has the voltage transfer characteristics as shown in the figure below. 4
$\boldsymbol{v_O}(\mathbf{V})$ is the **output voltage** and $\boldsymbol{v_I}(\mathbf{V})$ is the **input voltage**.



b) A valve is used to release (when valve is OPEN,) or maintain (when valve is CLOSED,) water pressure **10**
in a water tank. The valve operates on **ACTIVE LOW** logic. (i.e., the valve is OPENED when given a LOW voltage of $\mathbf{1\ V}$, but remains CLOSED when provided a HIGH voltage of $\mathbf{6\ V}$.)

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
$v_{0.5\,atm} = 0.5\ \mathrm{V}$	$v_{1\,atm} = 3\ \mathrm{V}$	$v_{low,\ 1.5\,atm} = 5.5\ \mathrm{V}$

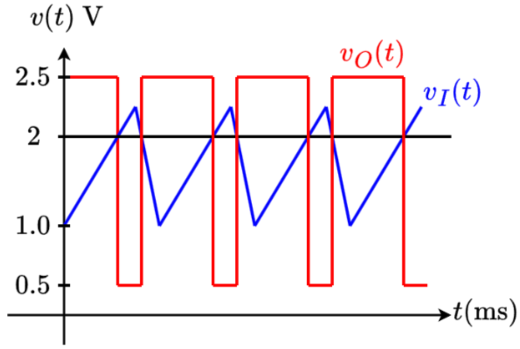
The pressure in the water tank can be measured by the formula $P = h\boldsymbol{\rho}g$, where $\boldsymbol{P}$, (in **Pascals (Pa)** unit) is the water pressure, $\boldsymbol{h}$ is the height of water in the tank (in $\mathbf{metres}$), $\boldsymbol{\rho}(= 1000\ \mathrm{kgm^{-3}})$ is the density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

[1 atm = 101325 Pa]

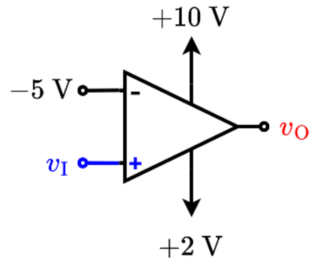
i. **Design** a circuit using Op-Amp comparator to automatically turn OPEN the valve if water level exceeds **10 m**.
ii. **Draw** the voltage transfer characteristics (VTC) of the designed Op-Amp.

Question 2: 10 Marks

a) Draw the voltage transfer characteristic (VTC) curve (v_O vs v_I) from the adjacent waveform graph. Also draw the **Op-Amp Circuit** that would give rise to such a VTC. [CO3] 3



b) Draw the voltage transfer characteristic (VTC) curve (v_O vs v_I) from the adjacent Op-Amp circuit. [CO2] 2

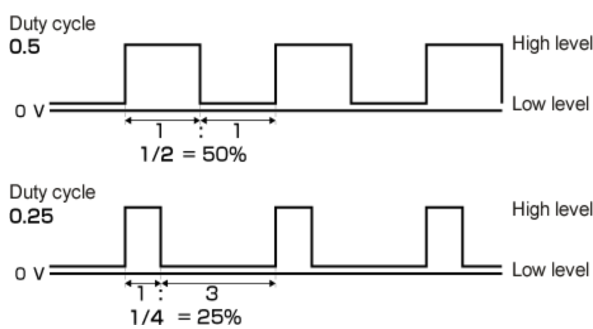


c) **Design** an op-amp circuit to transform the sinusoidal voltage, $v_I = 5 \cdot \sin\left(\frac{2\pi}{5} \cdot t\right)$ (− t is in units of **ms,** and time-period T is 5 ms), to: [CO3] 5
[You must evaluate V_{REF}]

i. A square wave with a duty cycle of **50%**.
ii. A square wave with a duty cycle of **25%**.

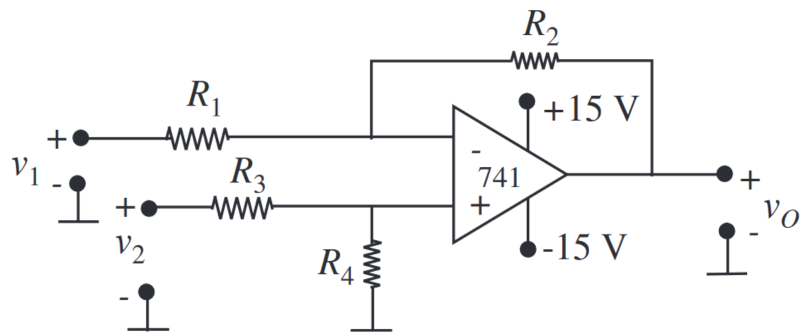
[**Duty Cycle:** Time of positive half cycle ÷ Time period]

For more information on duty cycle, click here!



[**Hint:** If $y = A \cdot \sin(\theta)$ is a sinusoidal function with period of 2π then $\theta = \sin^{-1}(\frac{y}{A})$ and $\pi - \sin^{-1}(\frac{y}{A})$. So, for 25% duty cycle find the value of y for which $\Delta\theta = \left(\pi - \sin^{-1}(\frac{y}{A})\right) - \sin^{-1}\left(\frac{y}{A}\right) = \frac{\text{Time period}}{4} = \frac{\pi}{2}$]

[CO2] Question 3: 10 Marks



Answer the following questions dealing with the above circuit.

a) Using the ideal Op Amp model, derive an expression for the output voltage $\boldsymbol{v_O}$ in terms of v_1, v_2, R_1, R_2, R_3, and R_4 4

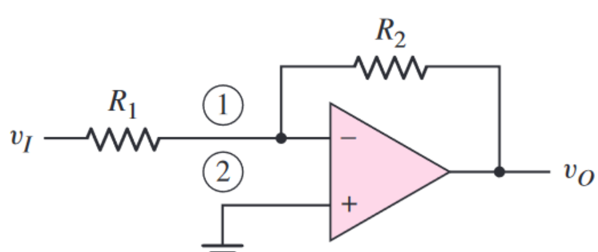
b) Does connecting a load resistor R_L between the output and ground change the previous expression for $\boldsymbol{v_O}$? Why? 2

c) Let $\boldsymbol{v_1} = \boldsymbol{v_2}$ and $\boldsymbol{R_1} = \mathbf{1\ k\Omega}$, $\boldsymbol{R_2} = \mathbf{30\ k\Omega}$, and $\boldsymbol{R_1} = \mathbf{1.5\ k\Omega}$. Find $\boldsymbol{R_4}$ so that $\boldsymbol{v_O} = \mathbf{0}$. 2

d) Let $\boldsymbol{v_2} = \mathbf{0}$ and $\boldsymbol{v_1} = \mathbf{1\ V}$. Using the preceding resistor values (including that computed for $\boldsymbol{R_4}$), find $\boldsymbol{v_O}$. 2

[CO3] Question 4: 6 Marks

Design the circuit below such that the closed loop voltage gain is $\boldsymbol{A_{\mathbf{CL}}} = \mathbf{-25}$. The maximum current in any resistor is to be limited to $\mathbf{10\ \mu A}$ with the input voltage in the range $-25 \le v_I \le 25\ \mathbf{mV}$.



a) What are the values of $\boldsymbol{R_1}$ and $\boldsymbol{R_2}$? 4

b) What is the range of output voltage $\boldsymbol{v_O}$? 2