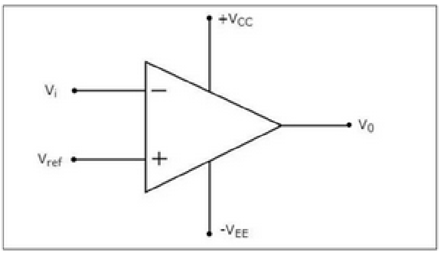
BRAC University

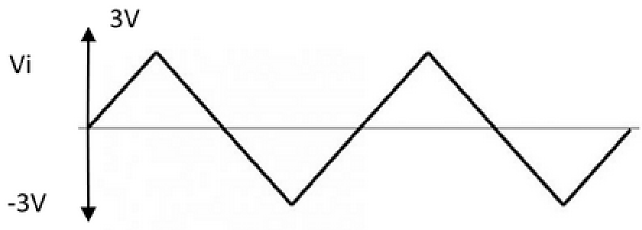
Semester: Spring 2024, Faculty: YAR

Course: CSE 251, Section: 02

Assignment: 02	Deadline: 22 Feb, 2024 (11:59 PM)	Total Marks: 100

Question: 01: [CO3] (5 marks)





VCC = 15V= -VEE , Vref = 1.5V, Vi is a 6V p-p triangular signal as shown below.

Question: 02: [CO3] (5+5 marks)

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 $metres$), $\rho(= 1000\ kgm^{-3})$ 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.

Question: 03: [CO3] (10 marks)

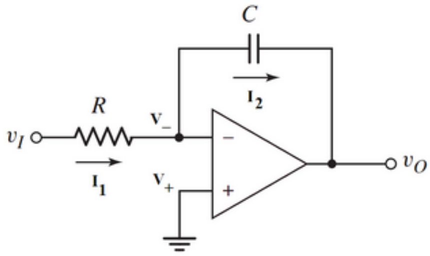


Figure 1 (a)

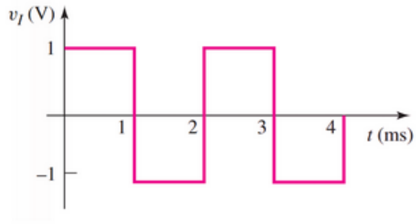


Figure 1 (b)

(a) **Analyze** the circuit drawn in Fig. 1(a) and **determine** the voltage values at the inverting and non-inverting nodes (V_- and V_+). [0.5+0.5]

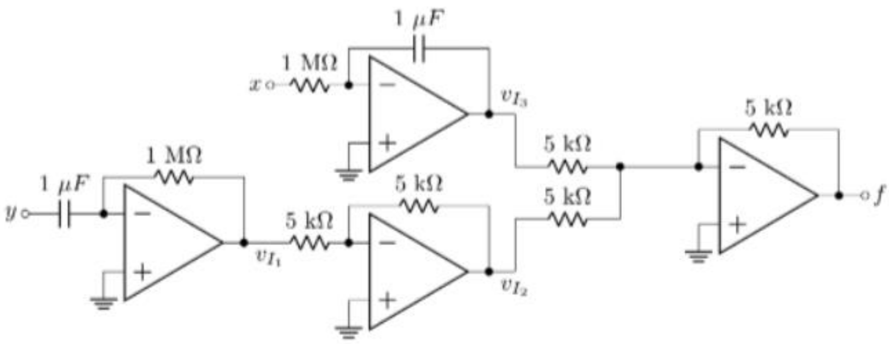
(b) **Identify** the relation between I_1 and I_2. [1]

(c) **Analyze** the circuit to derive the expression of output voltage V_0. You have to **show** all the steps. [3]

(d) Now consider the input wave v_1 given in Fig. 1(b). For circuit parameters R = 10 kΩ and C = 0.1μF, **determine** the output voltage at t = 1 ms. [1]

(e) **Design** a circuit using Op-Amps to implement the following expression: [4]
$f = \frac{1}{4}x + 7y - \frac{d}{dt}z$

Question: 04: [CO3] (10 marks)



(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]

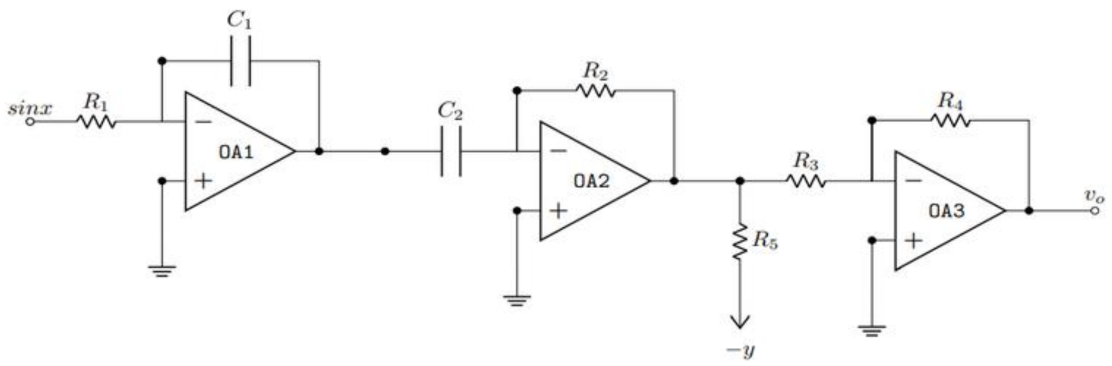
(b) Draw the circuit of an inverting amplifier and **design** it in such a way that the voltage gain, $k = -4$. (*i.e.*, find the values of R_1 and R_2). [3]

(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]

Question: 05: [CO3] **(5 marks)**

Deduce the output wave expression for the following circuit:



Question: 06: [CO3] **(2.5+2.5 marks)**

Design a circuit using op-amps to implement y=7x by an

(a) Inverting amplifier

(b) Non-inverting amplifier

Question: 07: [CO3] **(10 marks)**

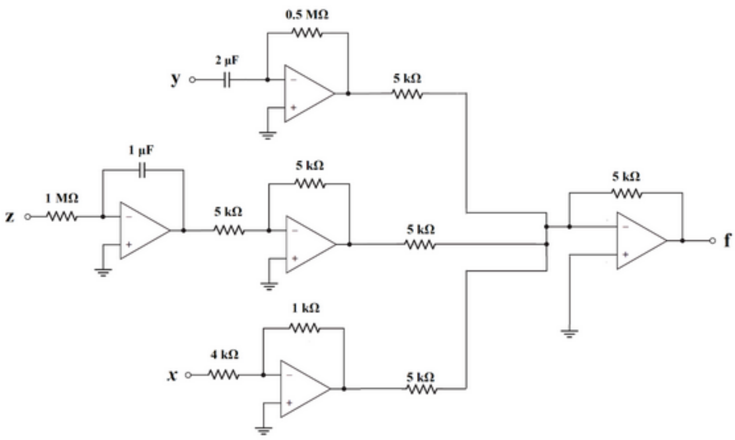


Figure 3(a)

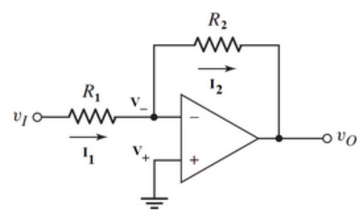


Figure 3(b)

(a) **Analyze** the circuit in Fig 3(a) to find an expression of f in terms of x, y, and z. [4]

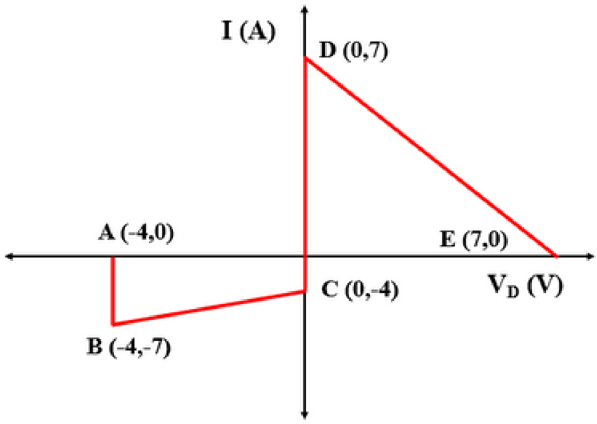
(b) **Design** an inverting amplifier (i.e., find the values of R_1 and R_2 of the circuit shown in Fig. 3(b)) in such a way that the voltage gain is **−4**. [3]

(c) **Draw** the input and output waveforms of the circuit you designed in (b). [2]

(d) Consider the circuit in Figure 3(b) again. Assume the inpurt $v_i = 0.1 \sin\omega t$ (V) has a maximum current rating of 4 µA. What design changes, if any, is required for this input, if the voltage gain remains the same?

Question: 08: [CO2] (5 marks)

Find out the slope of the following curves



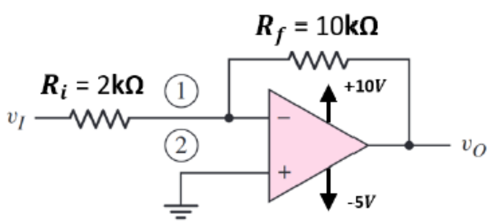
Question: 09: [CO3] (5 marks)

An automatic AC switching system using an Op-Amp comparator that will turn on automatically whenever the temperature is higher than 20° Celsius. The output waveform of an Op-Amp comparator should be between the voltage range **of [-4V 5V].** The temperature sensor used with the circuit produces a voltage signal of 1.5V for a temperature value of 20° Celsius.

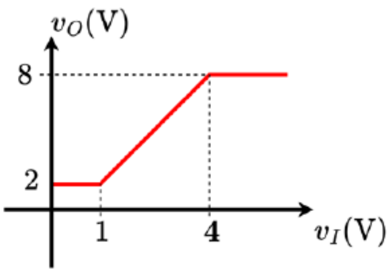
a) Design and draw the comparator circuit with the required inputs. [3]

b) Draw the VTC curve for your designed comparator. [2]

Question: 10: [Part 01] [CO3] (5 marks)



(i)



(ii)

(a) Draw the VTC curve for the circuit in Fig. (i). [3]

(b) Assume that the input signal for the circuit of Fig. (i) is $\boldsymbol{v_I} = \mathbf{0.1\ sin\ (\omega t)\ (V)}$. **Find out** the output. [2]

[Part 02] [CO3] (5 marks)

(a) Draw an Op-Amp circuit having the VTC shown in Fig. (ii). [2]
(b) Deduce the close loop gain for that Op-Amp circuit. [1]
(c) Determine the modification of this Op-Amp circuit which is required to implement a voltage-follower circuit and also draw the circuit. [2]

Question: 11: [CO3] (5 marks)

A Voltage Source, Vo= 10 V in series with a resistor of R= 3 $k\Omega$.

i. Write down the equation representing this curve
ii. Determine the unknown parameters
iii. Label the I-V curve

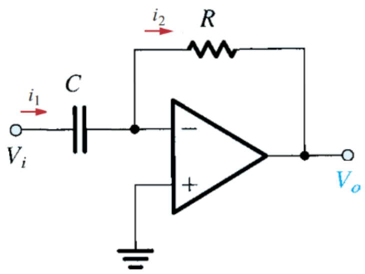
Question: 12: [CO3] (5 marks)

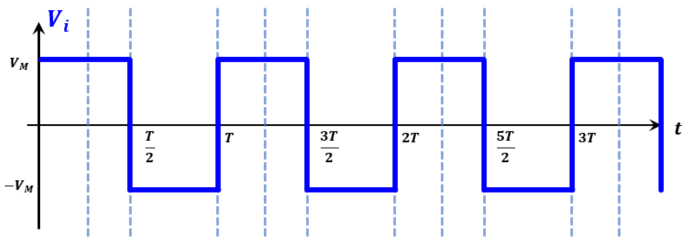
A Current Source, Io= 5 mA in parallel with a resistor of R= 5 $k\Omega$.

i. Write down the equation representing this curve
ii. Determine the unknown parameters
iii. Label the I-V curve

Question: 13: [CO3] (5 marks)

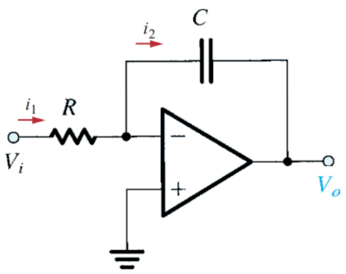
Find out the output waveform of this differentiator circuit:

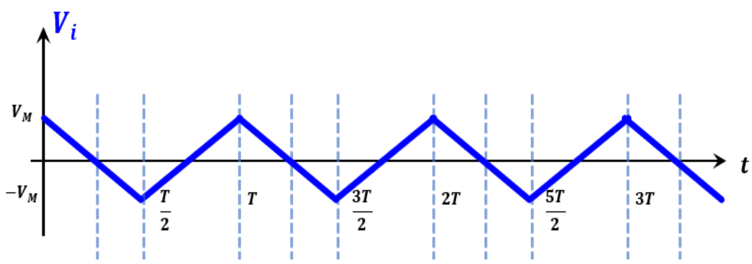




Question: 14: [CO3] (5 marks)

Find the output waveform of the following Op-Amp circuit:





Question: 15: [CO3] **(5 marks)**

Design an Op-Amp circuit with inputs V1, V2, and V3 to implement the following operational function: $V_o = 6V_1 - 10V_2 + 4V_3$