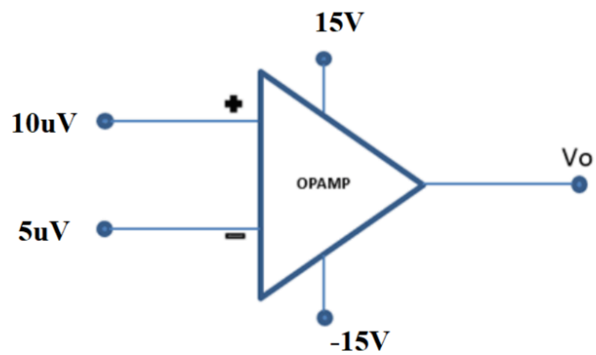
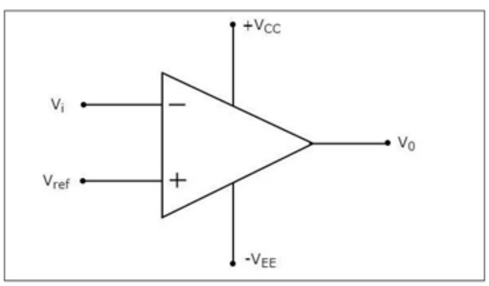
Op-Amp

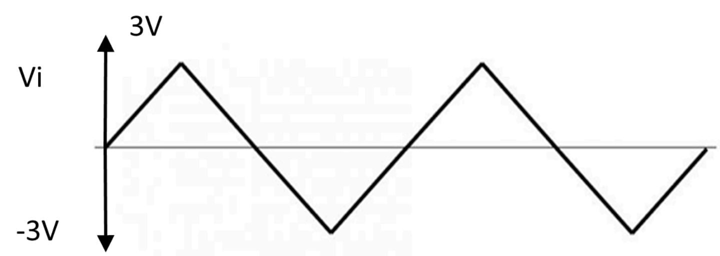
1. Observe the following circuit.



Calculate the value of Vo. Repeat the problem with V+=1 mV and V-=0.2 mV. Consider A=2105.

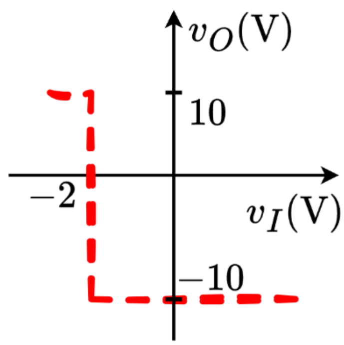
2. Draw output Vo for the following op-amp circuit.





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

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



5.

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.

6.

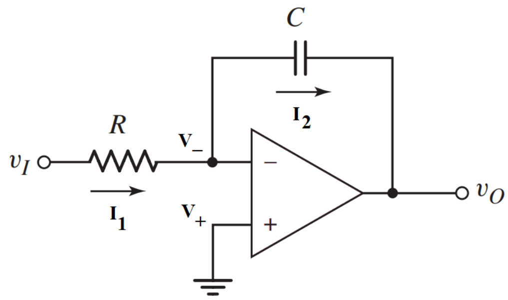


Figure 1 (a)

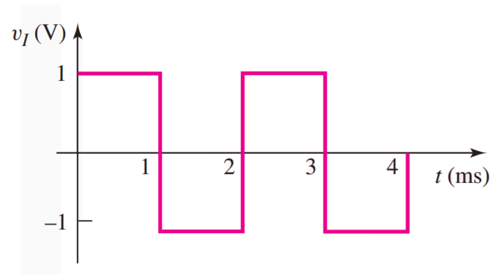


Figure 1 (b)

(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_o. 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]

$f = \frac{1}{4}x + 7y - \frac{d}{dt}z$

7.

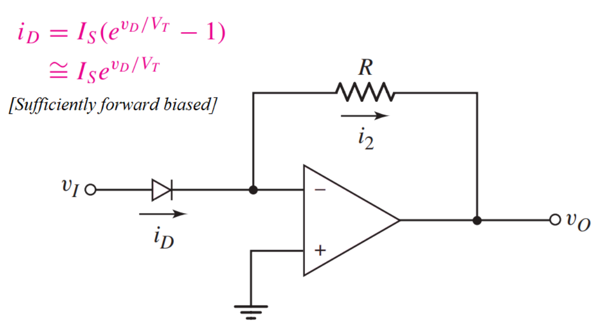


Figure 1

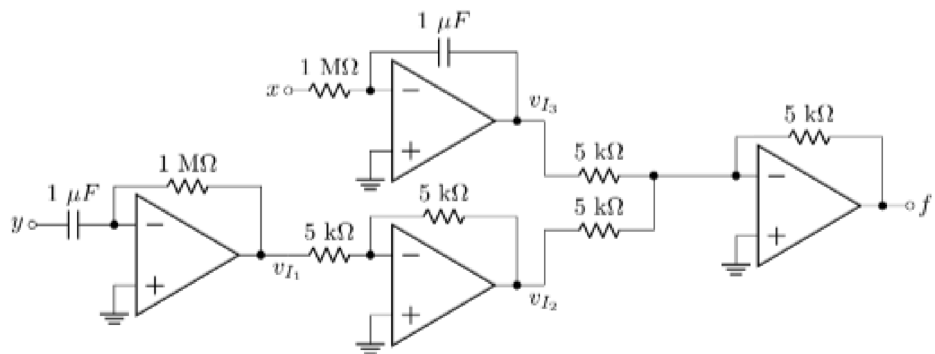
(a) **Analyze** the circuit drawn in Fig. 1 and **determine** the voltage values at the inverting and non-inverting nodes (V_- and V_+). [0.5+0.5]

(b) **Identify** and briefly explain the relation between i_2 and i_D. [1.5]

(c) **Analyze** the circuit to derive the expression of output voltage V_o. You have to **show** all the steps. [3.5]

(d) **Design** a circuit using Op-Amps to implement the following expression: [4]

8.



(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]

9.

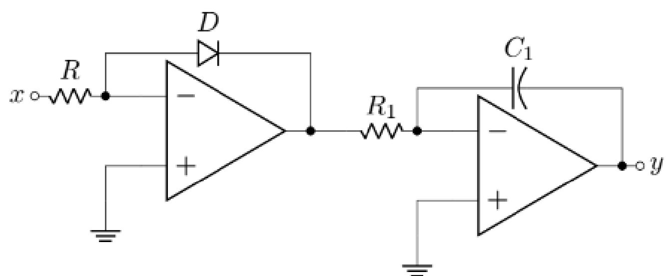
(a) **Design** a circuit using **Op-Amp comparator** to automatically turn ON (or OFF) the street lights. For this, you have a lux sensor installed on top of the street lights (facing above) that outputs a voltage proportional to amount of natural light, as listed below:

$v_{\text{night, 0 lux}} = 1$ V	$v_{\text{dusk, 20 lux}} = 2$ V	$v_{\text{dawn, 80 lux}} = 3$ V

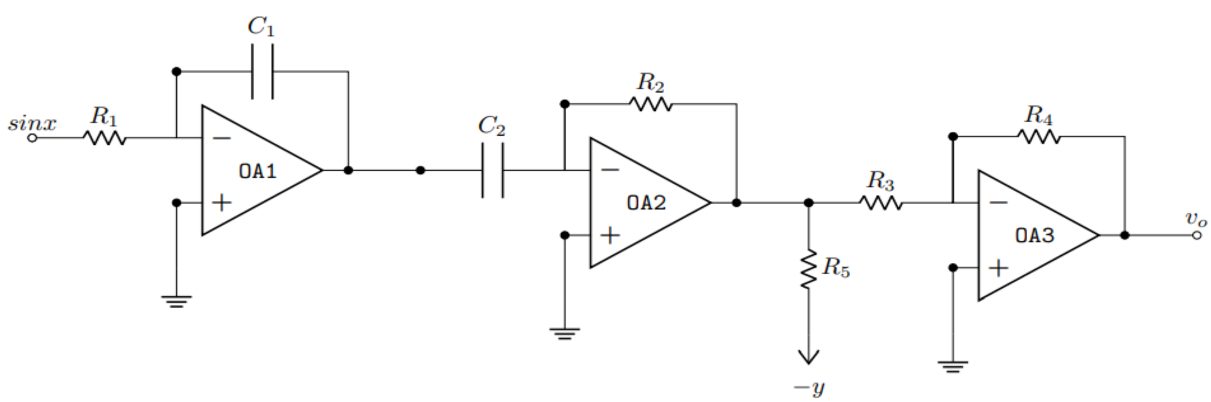
The lights require 20 V and should be ON if the amount of light goes ***below*** 20 lux (at dusk). [3]

(b) **Design** a circuit using Op-Amp to implement the expression: $f = -3\frac{dx}{dt} + 2\exp y + 4z$ [4]

(c) **Analyze** the circuit below to find y as a function of x. For the diode, $I_S R = 1$ and $V_T = 1$. [3]



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

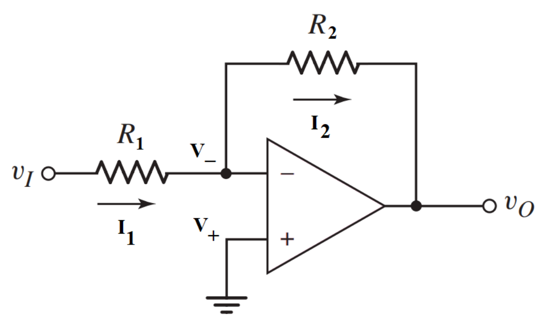


11. Design a circuit using op-amps to implement y=7x by an

(a) Inverting amplifier

(b) Non-inverting amplifier

12.

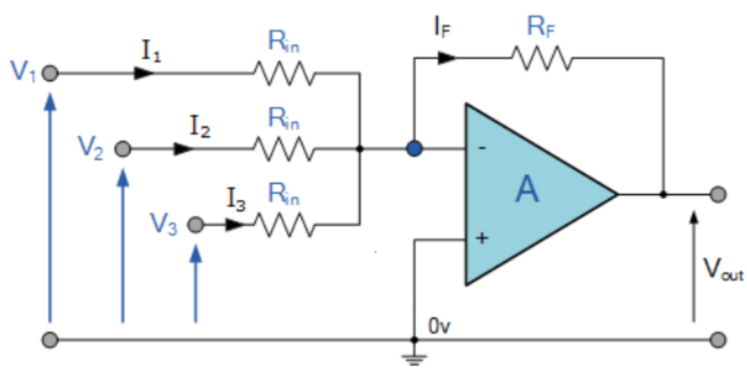


(a) **Design** an inverting amplifier (i.e., find the values of R_1 and R_2 of the circuit shown in the Figure above) in such a way that the voltage gain is **−5**.

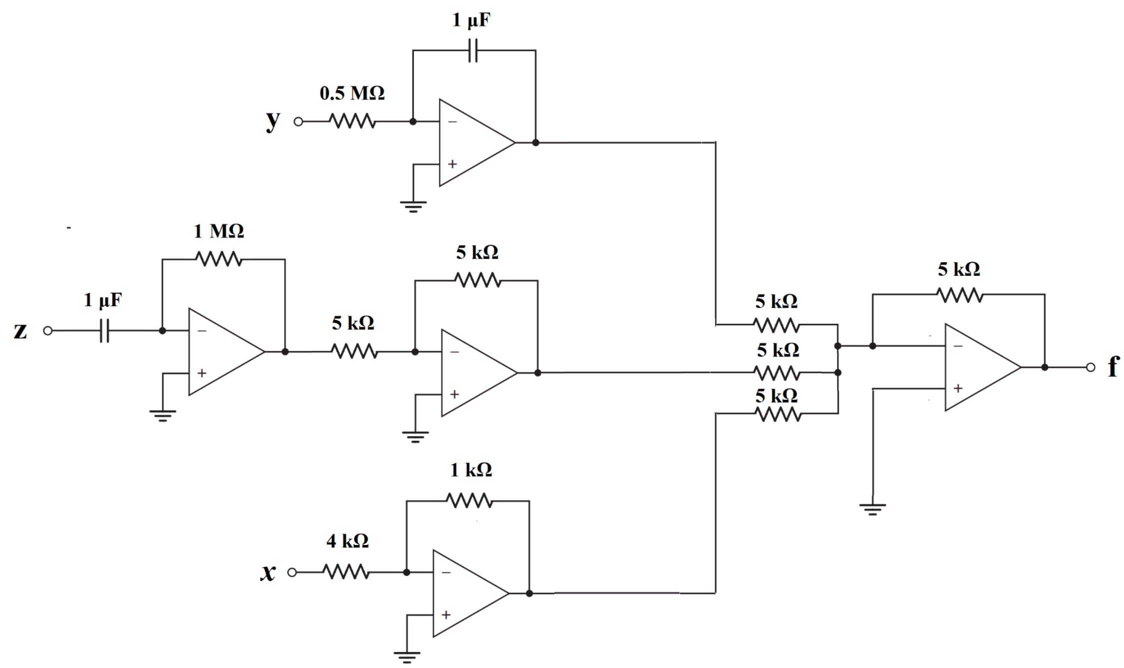
(b) Consider the circuit you drew in (a) again. Assume the input $v_i = 0.1 \sin\omega t$ (V) has a maximum current rating of 5 μA. What design changes, if any, are required for this input, if the voltage gain remains the same?

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

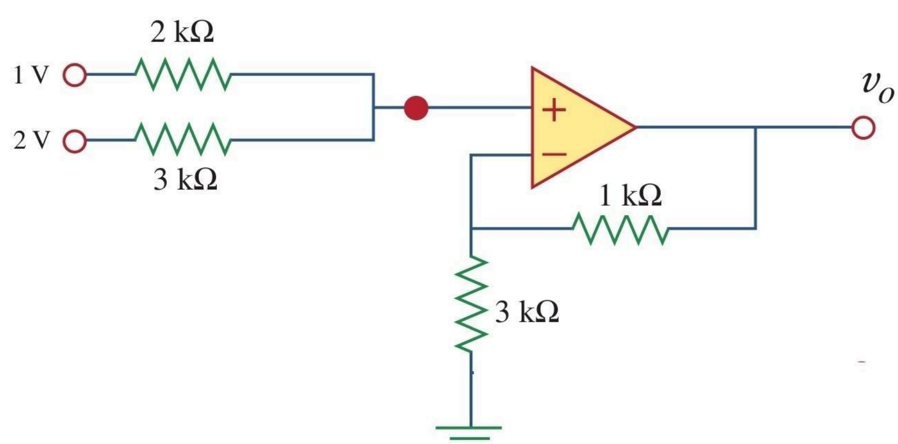
- **Analyze** the following circuit and derive the expression for the output voltage (V_{out}) in terms of the inputs. If V_1=1 V, V_2 = 2V, and V_3 = 1.5 V, and all the resistors have equal values, calculate V_{out}.



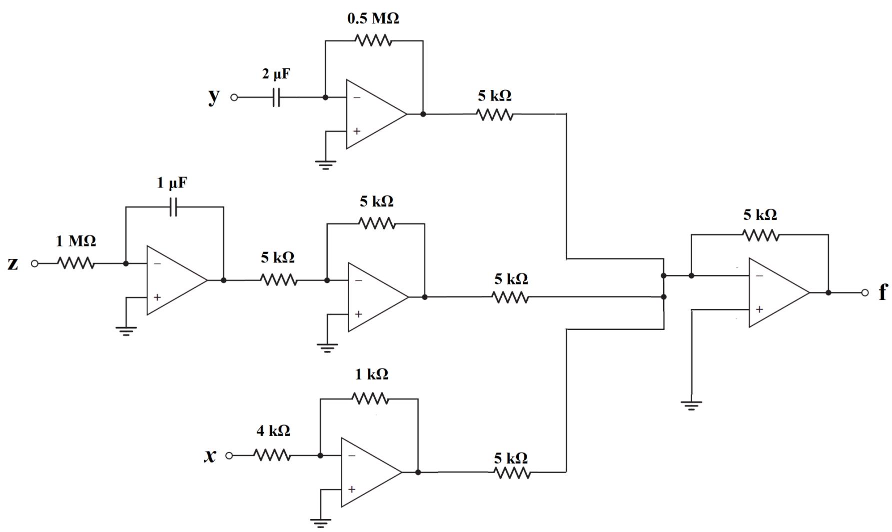
13. **Analyze** the following circuit to find an expression of f in terms of x, y, and z.



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



15.



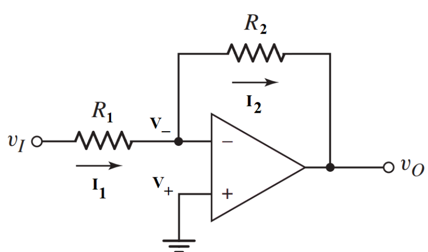


Figure 3(a) **Figure 3(b)**

(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?