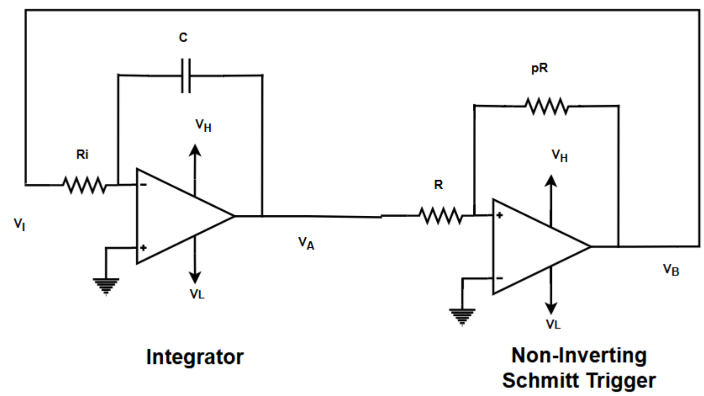
Question 01.

Answer the following question for the Triangular wave generator.

Given, $V_L = -V_H$

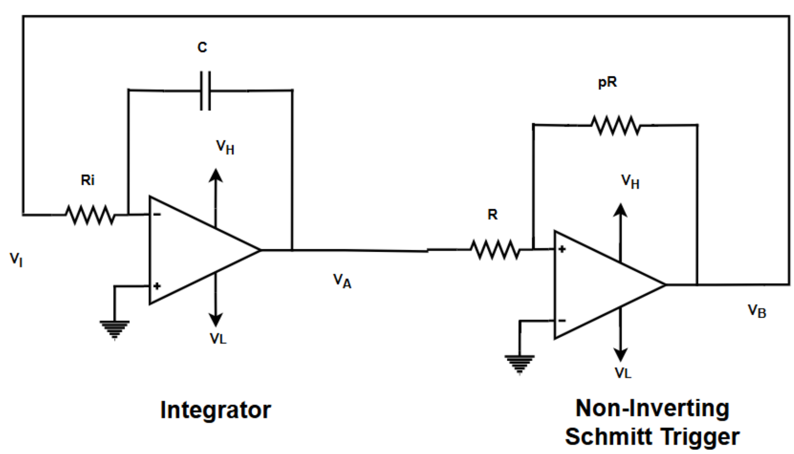


(a)	Prove that the frequency of the triangular wave, $f = \frac{P}{4R_iC}$.
(b)	Find the duty cycle of the triangular wave and find the duty cycle of the square wave. Is there any relation between these two duty cycles?
(c)	Draw the wave form of the square wave (V_A) and triangular wave (V_B).

Question 02.

Answer the following question for the Triangular wave generator.

Given, $R_i = 10k,\ C = 10\ \mu F\ ,\ R_2 = pR = 20k,\ \ R1 = R = 10k,\ V_L = -V_H$ or $V_H = 15\ V,\ V_L = -15\ V$



(a)	Find the value of upper threshold and lower threshold value of the Schmitt trigger used in the above triangular wave generator.
(b)	Draw the VTC of the Schmitt trigger used in the above triangular wave generator.
(c)	What is the frequency and time period of the triangular wave generator?

Question 03

Suppose you want to design a triangular wave generator circuit. Required frequency of the wave is 1 kHz.

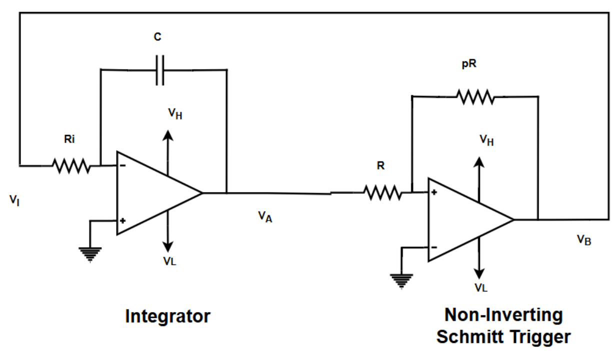
Duty cycle should be close to 50 %. You have +15V, -15 V power supply, 0.47 μF capacitor and different resistors.

(a)	Find the time period, rising time and falling time of the desired triangular wave.
(b)	Design a circuit to generate the required wave.
(c)	Suppose you have replaced the power supply of your designed circuit with +5V and -5V what will be new frequency and duty cycle of the triangular wave?

Question 04.

Answer the following question for the Triangular wave generator.

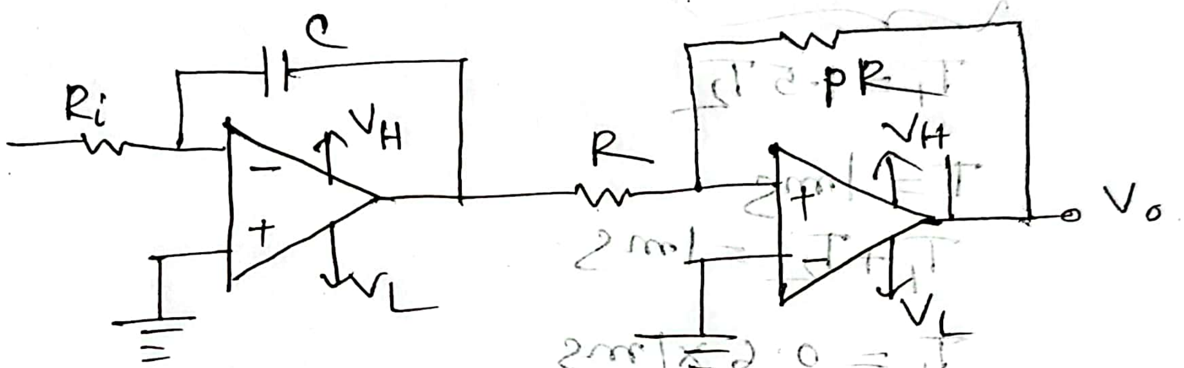
Given, $R_i = 10k,\ C = 10\ \mu F\ ,\ R_2 = pR = 20k,\ \ R1 = R = 10k,$ or $\mathrm{V_H} = 10\ \mathrm{V},\ \mathrm{V_L} = -8\ \mathrm{V}$



(a)	Find the values of $V_{TH}, V_{TL}, Falling\ time\ and\ Rising\ Time$ of the triangular wave generator.
(b)	What will be the duty cycle of the triangular wave and the square wave?

Triangular Wave Generator

Q1. a) Triangular wave generator,



Given, $V_L = -V_H$

$$V_{TH} = -\frac{V_L}{p} = \frac{V_H}{p} \quad [V_L = -V_H]$$

$$V_{TL} = -\frac{V_H}{p}$$

Now, $$T_1 = R_i C \frac{V_{TH} - V_{TL}}{V_H} = R_i C \frac{\frac{V_H}{p} + \frac{V_H}{p}}{V_H}$$

$$= \frac{2R_iC}{p}$$

$$T_2 = R_i C \frac{V_{TL} - V_{TH}}{V_L} = R_i C \frac{-\frac{V_H}{p} - \frac{V_H}{p}}{-V_H} \quad [V_L = -V_H]$$

$$= \frac{2R_iC}{p}$$

$$T = T_1 + T_2 = \frac{2R_iC}{p} + \frac{2R_iC}{p}$$

$$= \frac{4R_iC}{p}$$

$$\therefore f = \frac{1}{T} = \frac{p}{4R_iC} \quad [\text{proved}]$$

Q1.b) We know,

$$T_{1} = R_i C \frac{V_{TH} - V_{TL}}{V_H}$$

$$= R_i C \frac{\frac{V_H}{P} + \frac{V_H}{P}}{V_H}$$

$$= \frac{2R_iC}{P}$$

$V_H = -V_L$

$V_{TH} = \frac{V_H}{P}$

and, $V_{TL} = -\frac{V_H}{P}$

$$T_2 = R_i C \frac{V_{TL} - V_{TH}}{V_L}$$

$$= R_i C \frac{-\frac{V_H}{P} - \frac{V_H}{P}}{-V_H} = \frac{2R_iC}{P}$$

$$DC\ (Tri) = \frac{T_2}{T_1+T_2} \times 100\%$$

$$= \frac{\frac{2R_iC}{P}}{\frac{2R_iC}{P} + \frac{2R_iC}{P}} \times 100\% = 50\%$$

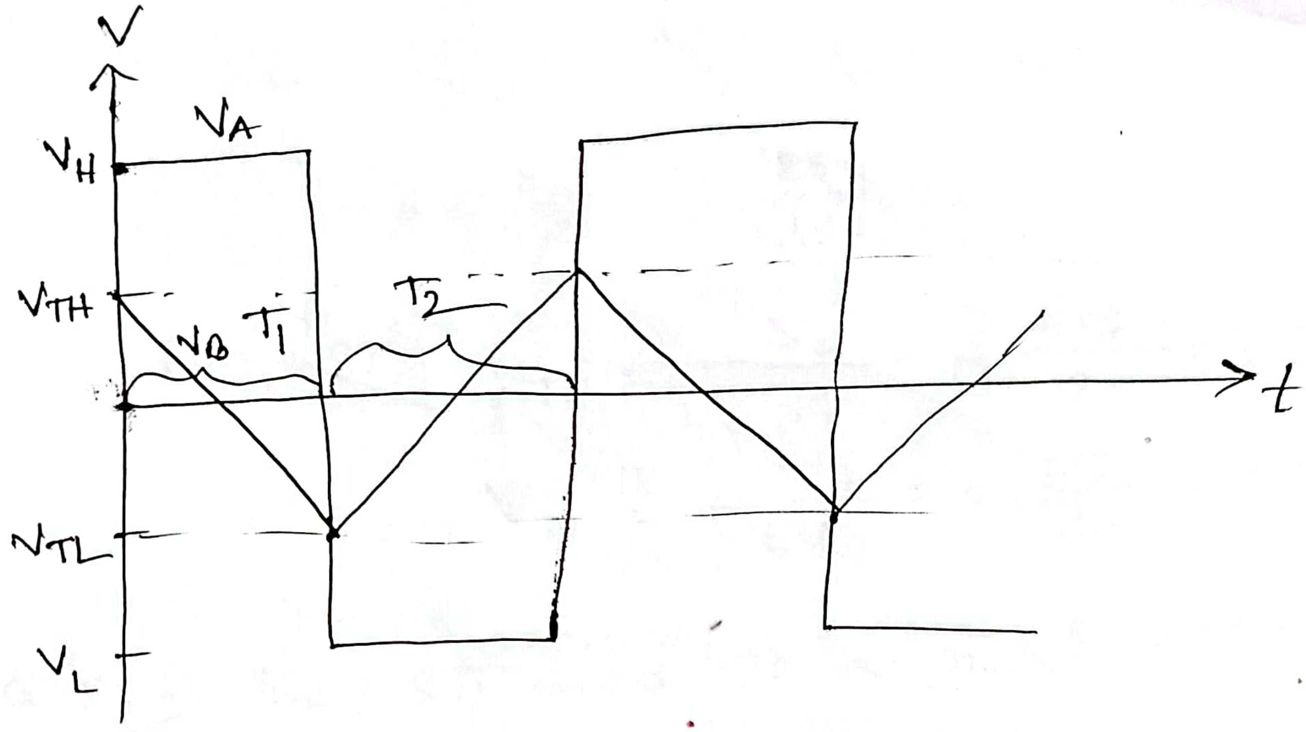
$$D.C.\ (Sq) = \frac{T_1}{T_1+T_2} \times 100\%$$

$$= \frac{\frac{2R_iC}{P}}{\frac{2R_iC}{P} + \frac{2R_iC}{P}} \times 100\% = 50\%$$

Yes, sum of the two duty cycles is 100%.

$$D.C.\ (Tri) + D.C.\ (Sq) = 100\%$$

Q.1.(c)



Q2. a) Here, $V_H = +15V$, $V_L = -15V$,

$$p = \frac{R_2}{R_1} = \frac{20}{10} = 2$$

For, ST, $V_{TH} = -\frac{V_L}{p} = -\frac{-15}{2} = 7.5V$

$$V_{TL} = -\frac{V_H}{p} = -\frac{15}{2} = -7.5$$

Q.2. b) The ST used is a non-inverting ST,

From (a), $V_{TH} = 7.5V$,

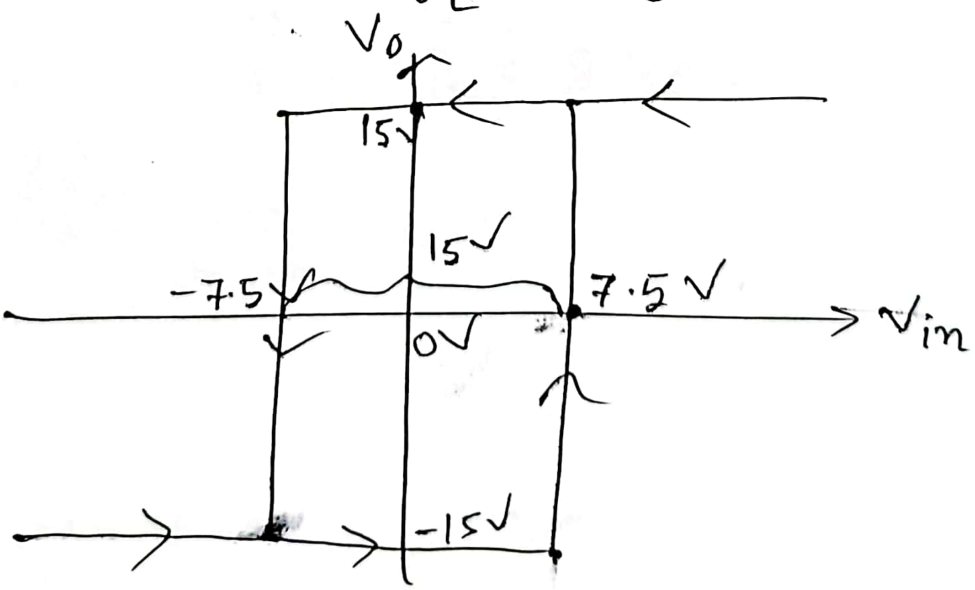
$V_{TL} = -7.5V$,

$$V_S = \frac{V_{TH} + V_{TL}}{2} = 0$$

$V_{HW} = V_{TH} - V_{TL} = 15V$

$V_H = +15V$

$V_L = -15V$



Q.2(c) As the power supply is symmetrical,

$$f = \frac{p}{4R_iC}, \quad p = \frac{R_2}{R_1} = 2$$

$$= \frac{2}{4 \times 10k \times 10\mu}$$

$$= 5\,Hz$$

$$T = \frac{1}{f} = \frac{1}{5} = 0.2\,s$$

Q.3. a) We know,

T_1 = Falling time

T_2 = Rising time

$$T = \frac{1}{f} = \frac{1}{1k} = 1ms$$

$$50\% = \frac{T_2}{T_1+T_2} \times 100\%$$

$$\Rightarrow \frac{1}{2} = \frac{T_2}{T_1+T_2}$$

$$\Rightarrow T_1 + T_2 = 2T_2$$

Again, $T = T_1 + T_2$

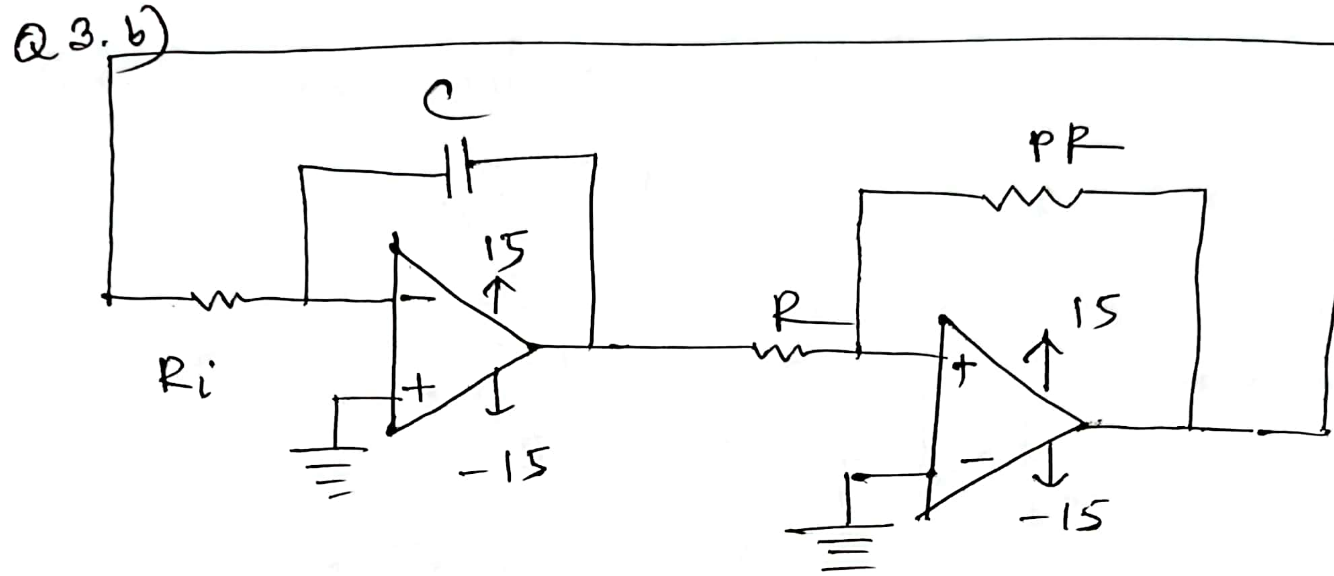
$$\Rightarrow T = T_1 + T_1 \quad [T_1 = T_2]$$

$$\Rightarrow T_1 = \frac{T}{2} = \frac{1ms}{2} = 0.5ms$$

$T = 1ms$

$T_1 = T_2 = 0.5ms$

Q 3. b)



Given, $C = 0.47\mu F$,

$V_L = -V_H$, $V_H = 15V$, $V_L = -15V$

$f = 1000 \, Hz$

From, symmetrical power supply,

$$f = \frac{p}{4 R_i C}$$

$$\Rightarrow 1000 = \frac{p}{4 \times R_i \times 0.47 \times 10^{-6}}$$

Now, we can assumpe, $p = 4$

$$1000 = \frac{4}{4 \times R_i \times 0.47 \times 10^{-6}}$$

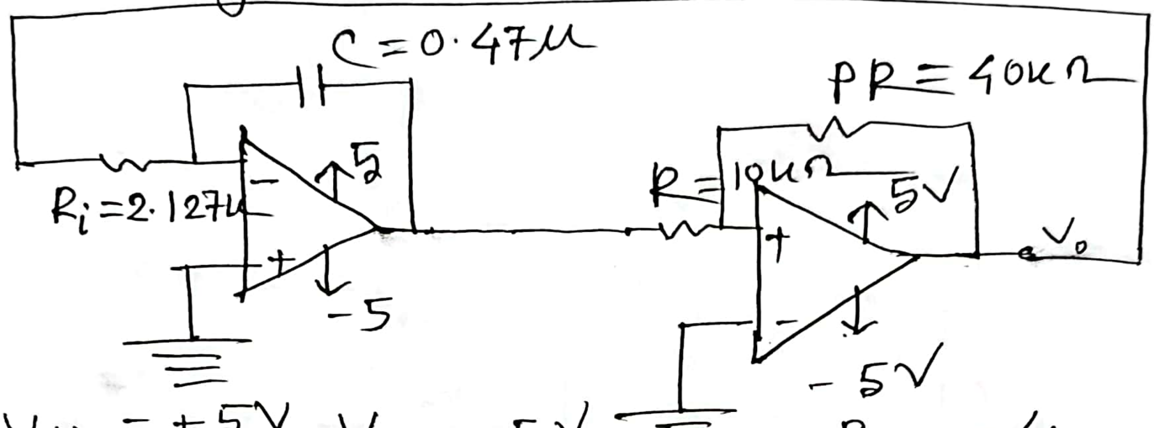
$$\Rightarrow R_i = 2.127 \, k\Omega$$

As, $p = \frac{R_2}{R_1}$, Assuming, $R_1 = 10k$,

$$\frac{R_2}{10k} = 4, \Rightarrow R_2 = 40K$$

Now, $R_i = 2.127 \, k\Omega$, $R_1 = 10k\Omega$, $R_2 = 40k\Omega$, $C = 0.47\mu F$

Q3.c) Designed circuit, with ± 5V supply



$V_H = +5V$, $V_L = -5V$, $p = \frac{R_2}{R_1} = 4$

$V_{TH} = -\frac{V_L}{p}$,

$= -\frac{-5}{4}$

$= 1.25V$

$V_{TL} = -\frac{V_H}{p} = -\frac{5}{4} = -1.25V$

$T_1 = R_iC \frac{V_{TH} - V_{TL}}{V_H}$

$= R_iC \frac{1.25 + 1.25}{5} = \frac{R_iC}{2}$

$T_2 = R_iC \frac{V_{TL} - V_{TH}}{V_L}$

$= R_iC \frac{-1.25 - 1.25}{-5}$

$= \frac{R_iC}{2}$

$T = T_1 + T_2$

$= \frac{R_iC}{2} + \frac{R_iC}{2}$

$= R_iC$

$f = \frac{1}{T}, = \frac{1}{R_iC} = \frac{1}{2.127 \times 10^3 \times 0.47 \times 10^{-6}}$

$= 1000$ Hz

Same as before.

Q4. a) Power supply not symmetrical,

Here, $p = \frac{R_2}{R_1} = \frac{20k}{10k} = 2$

$V_H = 10V$, $V_L = -8V$

$V_{TH} = -\frac{V_L}{p}$

$= -\frac{-8}{2}$

$= 4V$,

$V_{TL} = -\frac{V_H}{p}$

$= -\frac{10}{2}$

$= -5V$

Here, $\tau = R_i C = 10k \times 10\mu = 100\ ms$

$T_1 = 100ms \times \frac{4-(-5)}{10} = 90ms$

$T_2 = 100ms \times \frac{-5-4}{-8} = 112.5ms$

$V_{TH} = 4V$, $V_{TL} = -5V$, $T_1 = 90ms$, $T_2 = 112.5ms$

$T_1 \rightarrow$ falling time

$T_2 \rightarrow$ rising time

Q4. b) From (a), $T_1 = 90ms$, $T_2 = 112.5ms$

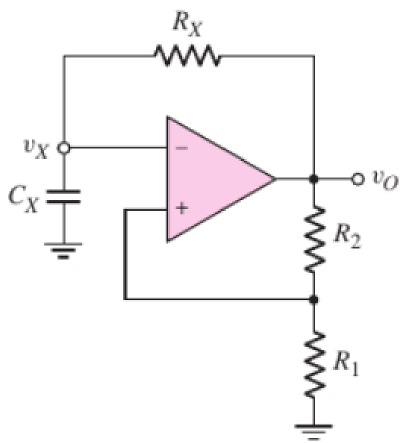
$DC(Tri) = \frac{T_2}{T_1+T_2} \times 100\% = 55.55\%$

$DC(Sq) = \frac{T_1}{T_1+T_2} \times 100\% = 44.44\%$

CamScanner

Square Wave Generator

1.

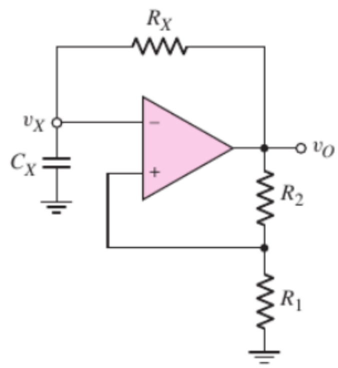


Here suppose R1 = 10k, R2 = 20k, Rx = 1k, Cx = 1 mF, VH= 10V and VL = -10 V

a. Find the period and frequency of the square wave?

b. What will be the value of the duty cycle of the square wave?
c. Draw the output waveform with proper labeling.

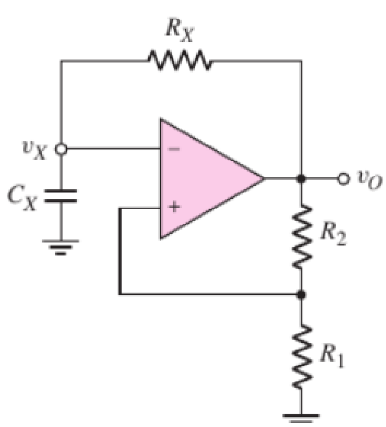
2.



Here VH = 10 V and VL = -10 V

Design the circuit so that it can generate a square wave with 1 kHz frequency and 50% duty cycle.

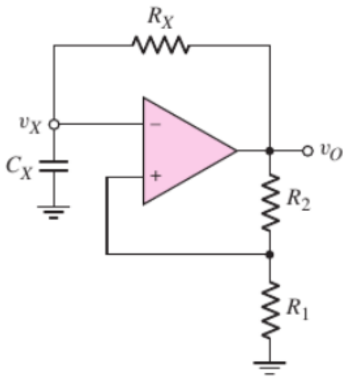
3.



suppose R1 = 10k, R2 = 20k, Rx = 1k, Cx = 1 mF

Design the circuit so that it can generate square wave with a 30% duty cycle. Find the frequency of your designed circuit.

4.



Here suppose R1 = 10k, R2 = 20k, Rx = 1k, Cx = 1 mF, VH = 10V and VL = -5V

Find out the duty cycle of inverted output signal of the above circuit.

1. a) $R1 = 10k$, $R2 = 20k$, $Rx = 1k$, $Cx = 1mF$,

$V_H = +10V$, $V_L = -10V$

$$V_{TH} = V_H \times \frac{R1}{R1+R2}$$

$$= 10 \times \frac{10}{10+20} = 3.33$$

$$V_{TL} = V_L \times \frac{R1}{R1+R2} = -3.33$$

$$\tau = R_x C_x = 1k \times 1m = 1s$$

$$T_1 = \tau \ln \frac{V_H - V_{TL}}{V_H - V_{TH}}$$

$$= 1 \times \ln \frac{10-(-3.33)}{10 - 3.33}$$

$$= 0.69s$$

$$T_2 = \tau \ln \frac{V_L - V_{TH}}{V_L - V_{TL}}$$

$$= 1 \times \ln \frac{-10-3.33}{-10-(-3.33)}$$

$$= 0.69s.$$

$$T = T_1 + T_2 = 0.69 + 0.69 = 1.38s$$

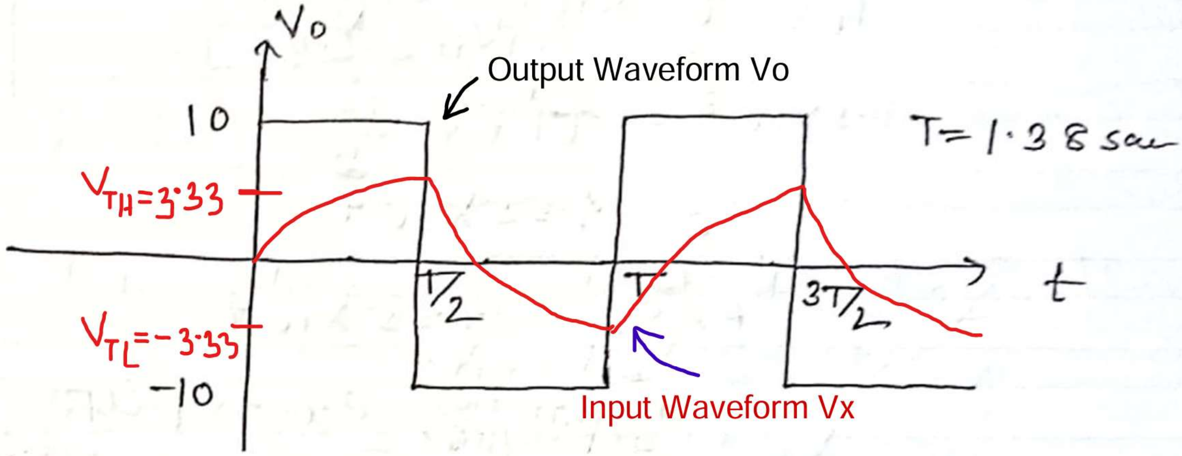
$$f = \frac{1}{T} = 0.72 \text{ Hz}$$

1.b) $\text{Duty cycle} = \frac{T_1}{T_1 + T_2} \times 100\%$

$$= \frac{0.69}{0.69 + 0.69} \times 100\%$$

$$= 50\%$$

1.c)



2. $V_H = 10V, \quad V_L = -10V$

Assuming, $R_1 = R_2 = 10k\Omega$

$$V_{TH} = V_H \times \frac{R_1}{R_1 + R_2} = 5V$$

$$V_{TL} = V_L \times \frac{R_1}{R_1 + R_2} = -5V$$

given, $f = 1kHz, \quad T = \frac{1}{f} = 1ms$

Duty cycle $= 50\%$ and, $T = T_1 + T_2$

$$\therefore \frac{T_1}{T_1+T_2} = 0.5, \Rightarrow T_1 = T_2 = T/2$$
$$= 0.5\times10^{-3}$$

$$T_1 = \tau \ln \frac{V_H - V_{TL}}{V_H - V_{TH}}$$

$$0.5\times10^{-3} = \tau \ln \frac{15}{5}$$

$$\tau = 4.55\times10^{-4}$$

$$R_x C_x = 4.55\times10^{-4}$$

assuming, $C_x = 1\mu F$

$$R_x = \frac{4.55\times10^{-4}}{C_x}$$

$$= 455\,\Omega$$

3. ime constant $\Rightarrow$ $\tau = R_x . C_x = 1k\Omega \times 1mF$

$= 1\times10^3 \times 1\times10^{-3} = 1 sec$

given, square wave duty cycle $\Rightarrow$ 30%

means, $\frac{T_1}{T_1+T_2} \times 100\% = 30\%$

$\Rightarrow \frac{T_1}{T_1+T_2} = 0.3$

$\Rightarrow T_1 = 0.3T_1 + 0.3T_2$

$\Rightarrow 0.7T_1 = 0.3T_2$

$\Rightarrow \boxed{7T_1 = 3T_2} \rightarrow$ Relation between high & low times

we know, $T_1 = \tau \ln \frac{V_H - V_{TL}}{V_H - T_{TH}}$

$R_1 = 10k\Omega$

$R_2 = 20k\Omega$

$\therefore \frac{R_1}{R_1+R_2} = \frac{10}{30}$

$= 1/3 = 0.33$

$= \tau \ln \frac{V_H - \left(\frac{R_1}{R_1+R_2}\right)\times V_L}{V_H - \left(\frac{R_1}{R_1+R_2}\right)\times V_H}$

$= 1 \times \ln \frac{V_H - \frac{V_L}{3}}{V_H - V_H/3}$

$= 1 \times \ln \frac{\frac{3V_H - V_L}{3}}{2V_H/3}$

$$\boxed{T_1 = 1 \times \ln \frac{3V_H - V_L}{2V_H}}$$

$T_2 = \tau \ln \frac{V_L - V_{TH}}{V_L - V_{TL}}$

$= \tau \ln \frac{V_L - \left(\frac{R_1}{R_1+R_2}\right)V_H}{V_L - \left(\frac{R_1}{R_1+R_2}\right)V_L}$

$$\boxed{T_2 = 1 \ln \frac{3V_L - V_H}{2V_L}}$$

Now, $\boxed{7T_1 = 3T_2}$

$$7 \ln \frac{3V_H - V_L}{2V_H} = 3 \ln \frac{3V_L - V_H}{2V_L}$$

as, there is two unknowns V_H and V_L in the equation, let's suppose $\rightarrow$ $\boxed{V_H = 10V}$

$$7 \ln \frac{30 - V_L}{20} = 3 \ln \frac{3V_L - 10}{2V_L}$$

using calculator, we get $\rightarrow$

$$\boxed{V_L = 10}$$

$$\therefore T_1 = 1 \times \ln \frac{30-10}{20}$$
$$= 0 \text{ sec}$$

$$\therefore T_2 = 1 \times \ln \frac{30-10}{20}$$
$$= 0 \text{ sec}$$

$$\therefore T = T_1 + T_2 = 0 \text{ sec}$$

$$f = \frac{1}{0} = \infty \text{ Hz}$$

4. $\tau = R_x C_x = 1s$

$V_H = +10V, \quad V_L = -5V$

$$V_{TH} = V_H \frac{R1}{R1+R2} = 10 \times \frac{10}{10+20} = 3.33$$

$$V_{TL} = V_L \frac{R1}{R1+R2} = -5 \times \frac{10}{10+20} = -1.67$$

$$T_1 = \tau \times \ln \frac{V_H - V_{TL}}{V_H - V_{TH}}$$

$$= 1 \times \ln \frac{10 - (-1.67)}{10 - 3.33} = 0.559$$

$$T_2 = \tau \ln \frac{V_L - V_{TH}}{V_L - V_{TL}} = 1 \times \ln \frac{-5 - 3.33}{-5 - (-1.67)}$$

$$= 0.91\ sec$$

$$\text{Duty cycle} = \frac{T_1}{T_1 + T_2} \times 100\% = 37.9\%$$