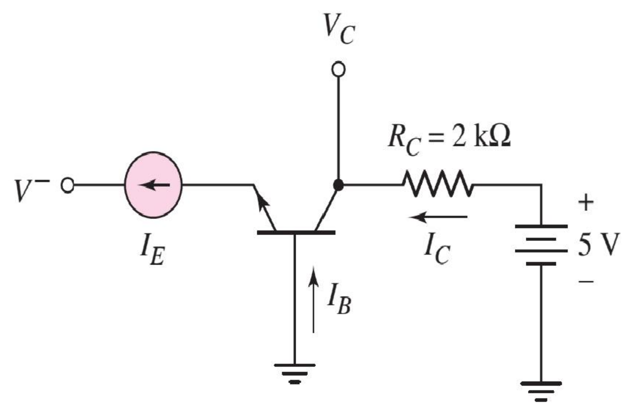
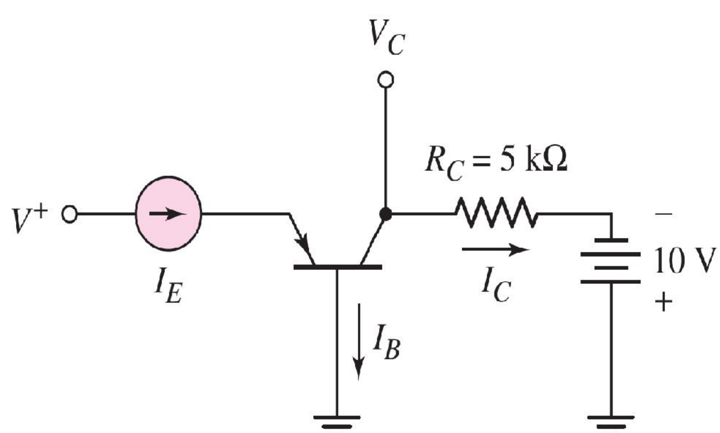
An npn transistor with $\beta = 80$ is connected in a common-base configuration as shown in Figure. (a) The emitter is driven by a constant-current source with $I_E = 1.2$ mA. Determine $I_B$, $I_C$, $\alpha$, and $V_C$. (b) Repeat part (a) for $I_E = 0.80$ mA. (c) Repeat parts (a) and (b) for $\beta = 120$.




A pnp transistor with $\beta = 60$ is connected in a common-base configuration as shown in Figure. (a) The emitter is driven by a constant-current source with $I_E = 0.75$ mA. Determine $I_B$, $I_C$, $\alpha$, and $V_C$. (b) Repeat part (a) if $I_E = 1.5$ mA. (c) Is the transistor biased in the forward-active mode for both parts (a) and (b)? Why or why not?



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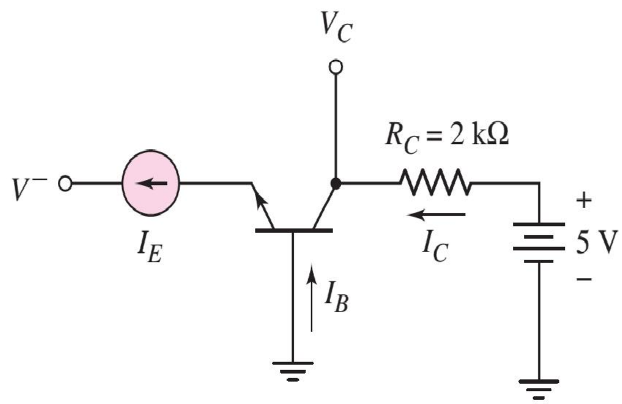



(a) $I_B = \dfrac{I_E}{1+\beta} = \dfrac{1.2}{81} \Rightarrow I_B = 14.8\ \mu\text{A}$

$I_C = \left(\dfrac{\beta}{1+\beta}\right)\cdot I_E = \left(\dfrac{80}{81}\right)(1.2) = 1.185\ \text{mA}$

$\alpha = \dfrac{80}{81} = 0.9877$

$V_C = 5 - (1.185)(2) = 2.63\ \text{V}$

(b) $I_B = \dfrac{0.8}{81} \Rightarrow I_B = 9.88\ \mu\text{A}$

$I_C = \left(\dfrac{80}{81}\right)(0.8) = 0.790\ \text{mA}$

$\alpha = 0.9877$

$V_C = 5 - (0.790)(2) = 3.42\ \text{V}$

(c) (i) $I_B = \dfrac{1.2}{121} \Rightarrow I_B = 9.92\ \mu\text{A}$

$I_C = \left(\dfrac{120}{121}\right)(1.2) = 1.19\ \text{mA}$

$\alpha = \dfrac{120}{121} = 0.9917$

$V_C = 5 - (1.19)(2) = 2.62\ \text{V}$

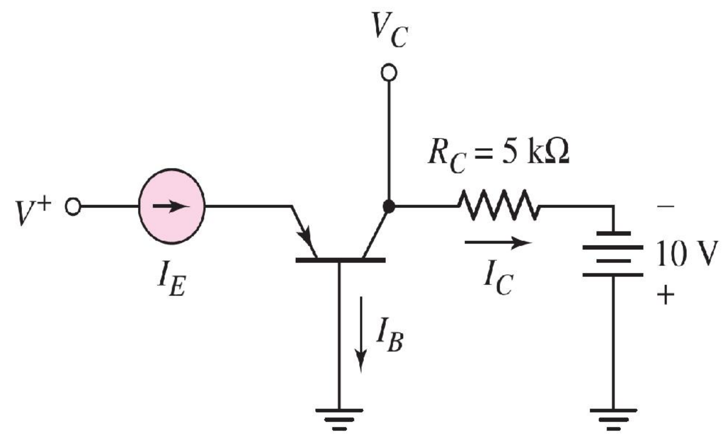
(ii) $I_B = \dfrac{0.8}{121} \Rightarrow I_B = 6.61\ \mu\text{A}$

$I_C = \left(\dfrac{120}{121}\right)(0.8) = 0.7934\ \text{mA}$

$\alpha = 0.9917$

$V_C = 5 - (0.7934)(2) = 3.41\ \text{V}$

A pnp transistor with $\beta = 60$ is connected in a common-base configuration as shown in Figure. (a) The emitter is driven by a constant-current source with $I_E = 0.75$ mA. Determine $I_B$, $I_C$, $\alpha$, and $V_C$. (b) Repeat part (a) if $I_E = 1.5$ mA. (c) Is the transistor biased in the forward-active mode for both parts (a) and (b)? Why or why not?




$$I_B = \frac{0.75}{61} \Rightarrow 12.3\ \mu\text{A}$$

$$I_C = (0.75)\left(\frac{60}{61}\right) = 0.738\ \text{mA}$$

$$\alpha = \frac{60}{61} = 0.9836$$

$$V_C = I_C R_C - 10 = (0.738)(5) - 10$$

a) $$V_C = -6.31\ \text{V}$$

$$I_B = \frac{1.5}{61} \Rightarrow 24.6\ \mu\text{A}$$

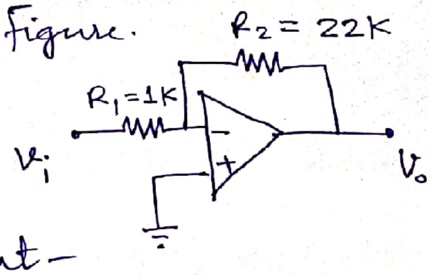
$$I_C = (1.5)\left(\frac{60}{61}\right) = 1.475\ \text{mA}$$

$$\alpha = \left(\frac{60}{61}\right) = 0.9836$$

b) $$V_C = (1.475)(5) - 10 \Rightarrow V_C = -2.625\ \text{V}$$

c) Yes, $V_C < 0$ in both cases so that B-C junction is reverse biased.

1. Consider the circuit shown in Figure.

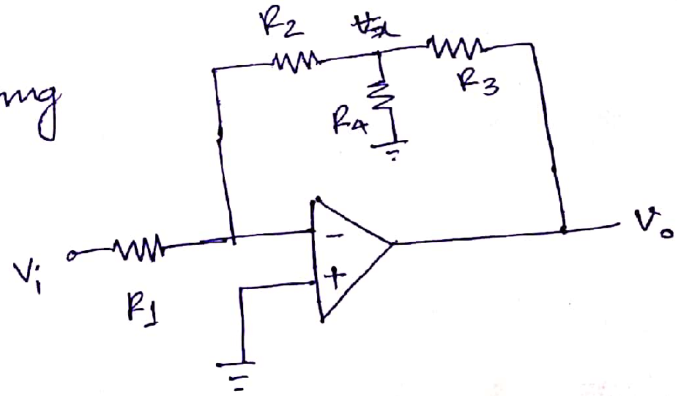



a) Determine the ideal output voltage $v_o$ if $v_i = -0.40$ V

b) Determine the actual output voltage if the open-loop gain of the op-amp is $A_{od} = 5 \times 10^3$

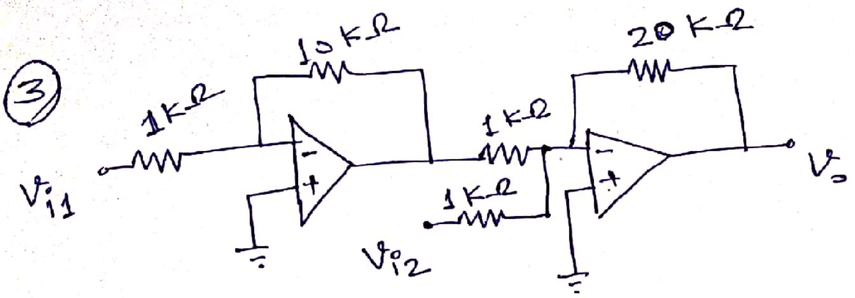
c) Determine the required value of $A_{od}$ in order that the actual voltage gain be within 0.2 % of the ideal value.

2) For the ideal inverting op-amp circuit with T-network, shown in Figure,




the circuit parameters are $R_1 = 10\,K\Omega$, $R_2 = R_3 = 50\,K\Omega$, and $R_4 = 5\,K\Omega$. Determine the closed loop-voltage gain.

(3)

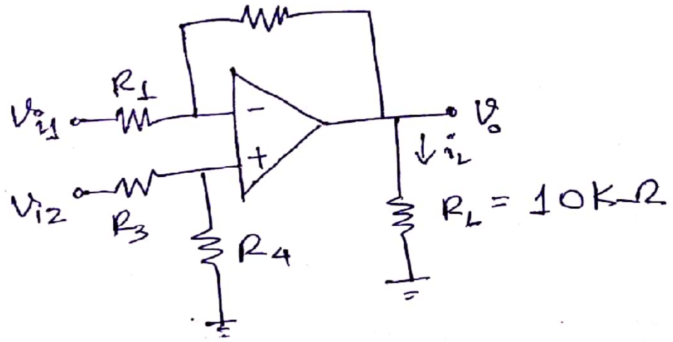



~~Derive the~~

Determine $v_o$ for $v_{i1} = +5$ mV and $v_{i2} = -25 - 50 \sin \omega t$ mV

(4) Consider the difference amplifier given.

Let $R_1 = R_3$ and $R_2 = R_4$.




a) Design the circuit such that the diffence voltage gain is $A_d = 15$ and the minimum difference input resistance is 30 KΩ.

b) If the load current is $i_L = 0.25$ mA, what is the differential input voltage $(v_{i2} - v_{i1})$ ?

Ans :

① a) $v_o = \frac{-R_2}{R_1} \cdot v_i = \left(\frac{-22}{1}\right)\overset{(-)}{(0.40)} = \underline{8.8\,V}$

b)

$$A_v = \frac{-R_2}{R_1} \cdot \frac{1}{\left[1 + \frac{1}{A_{od}}\left(1 + \frac{R_2}{R_1}\right)\right]} = -22 \cdot \frac{1}{1 + \frac{1}{5\times10^3}\times 23}$$

$$= -21.8993$$

$$v_o = (-21.8993)(-0.40) = \underline{8.7597\,V}$$

c) $A_v = -0.998 \times 22 = -21.956$

$$-21.956 = -22 \times \frac{1}{1 + \frac{1}{A_{od}} \times 23} \Rightarrow A_{od} = 1.1477\times10^4$$

② $$A_v = \frac{-R_2}{R_1}\left(1 + \frac{R_3}{R_4} + \frac{R_3}{R_2}\right)$$

$$= \frac{-50}{10}\left(1 + \frac{50}{5} + \frac{50}{50}\right) = \underline{\underline{-60}}$$

3) $V_o = \left(\frac{-10}{1}\right)\left(\frac{-20}{1}\right) \times v_{i1} + \left(\frac{-20}{1}\right) v_{i2}$

$= 200\, v_{i1} - 20\, v_{i2}$

$= 200 \times 5 - 20\,(-25 - 50 \sin \omega t)$

$= 1000 + 500 + 1000 \sin \omega t \; (mV)$

$= 1.5 + 1 \sin \omega t \; (V)$

(4)

a) $R_{id} = R_1 + R_3 = 30\, k\Omega$

$\therefore \; R_1 = R_3 = 15\, k\Omega$

$A_d = \frac{R_2}{R_1} = \frac{R_4}{R_3} = 15 \Rightarrow R_2 = R_4 = 225\, k\Omega$

b) $V_o = i_L R_L = 0.25 \times 10 = 2.5\, V$

$v_{i2} - v_{i1} = \frac{V_o}{A_d} = \frac{2.5}{15} = 0.1667\, V$

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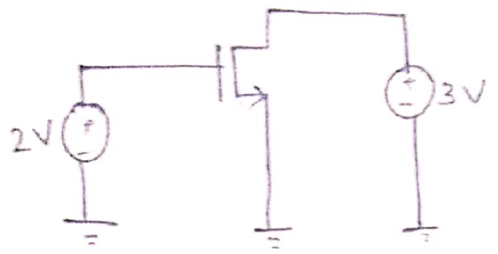
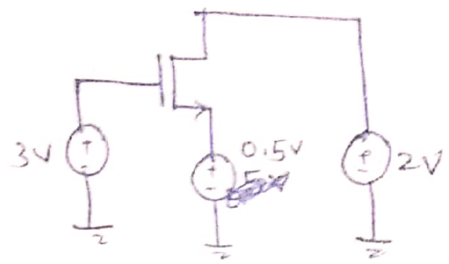
1. For the following circuit configurations, find the region of operation of the transistor. Consider threshold Voltage of n-mos transistor to be 0.6V.

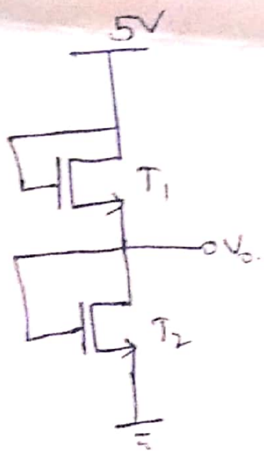
(a)




(b)




2. Both transistors $T_1$ & $T_2$ shown in the figure have a threshold Voltage of 1V. The device parameters $K_1$ & $K_2$ of transistors $T_1$ & $T_2$ are $36\mu A/V^2$ & $9\mu A/V^2$ respectively. Find the Voltage $V_0$.



1. a) $V_{GS} = 2 - 0 = 2V$

$V_{DS} = 3V$

$V_{GS} = 2V > \underset{(0.6V)}{V_T} \Rightarrow$ Transistor is ON

$V_{GS} - V_T = 2 - 0.6 = 1.4 < V_{DS} \Rightarrow$ Transistor is in Saturation region

b) $V_{GS} = 3 - 0.5 = 2.5V$

$V_{DS} = 2 - 0.5 = 1.5V$

$V_{GS} > V_T \Rightarrow$ Transistor is ON

$V_{GS} - V_T = 2.5 - 0.6 = 1.9V > V_{DS} \Rightarrow$ Transistor is in Linear region

2) $I_{DS}(T_1) = I_{DS}(T_2)$

& $T_1, T_2$ are in saturation (Gate & Drain are connected)

$$\cancel{\tfrac{1}{2}} K_1 [V_{GS_1} - V_T]^2 = \cancel{\tfrac{1}{2}} K_2 [V_{GS_2} - V_T]^2$$

$$\overset{4}{\cancel{36}} [5 - V_0 - 1]^2 = \cancel{4} [V_0 - 1]^2$$

$$\Rightarrow 2 = \frac{V_0 - 1}{4 - V_0}$$

$$\Rightarrow 8 - 2V_0 = V_0 - 1$$

$$\Rightarrow \boxed{V_0 = 3V}$$

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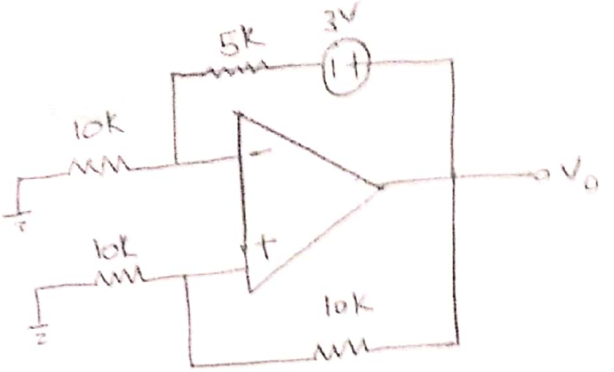
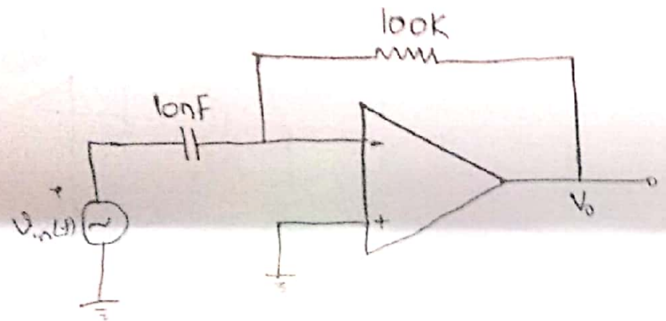
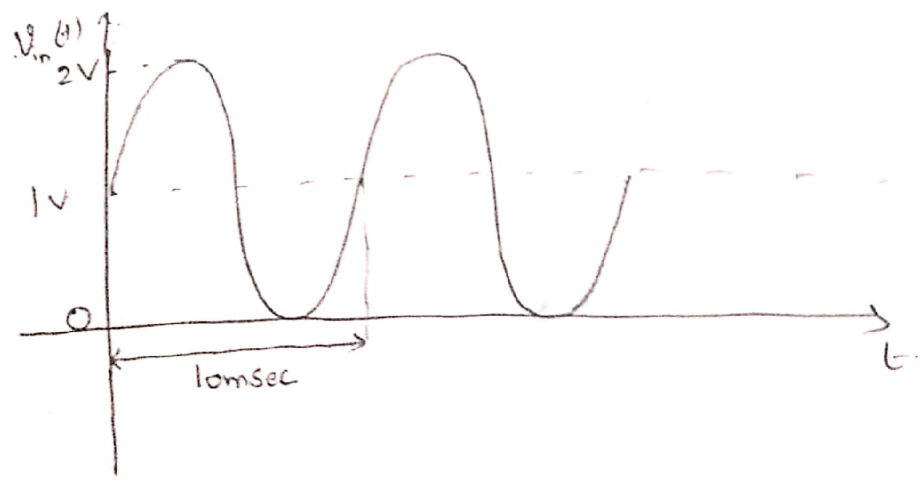
1. For the circuit shown below, find the Voltage $V_o$

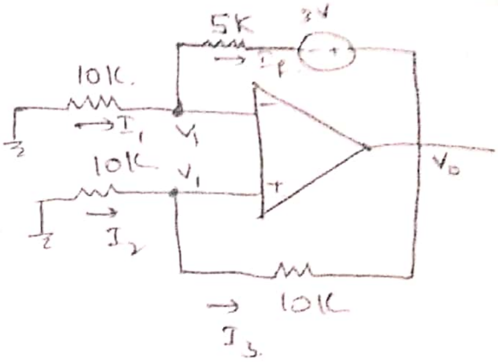



2. For the differentiator circuit, shown below, sketch the o/p waveform for the given i/p voltage.



1) A) $I_1 = I_f$




$$\Rightarrow \frac{0-V_1}{\cancel{10K}_{2}} = \frac{V_1 - V_o + 3}{\cancel{5K}}$$

$$-V_1 = 2V_1 - 2V_o + 6$$

$$\Rightarrow 2V_o = 3V_1 + 6 \longrightarrow (1)$$

$$I_2 = I_3$$

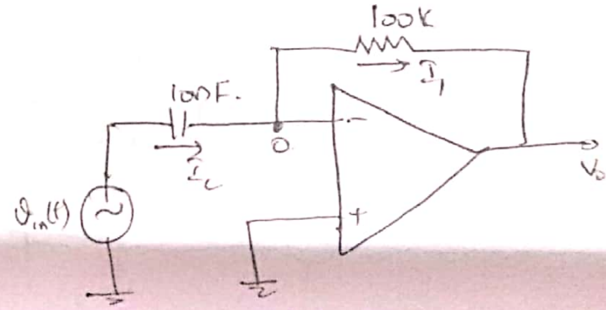
$$\Rightarrow \frac{0-V_1}{\cancel{10K}} = \frac{V_1 - V_o}{\cancel{10K}}$$

$$\Rightarrow 2V_1 = V_o \Rightarrow \boxed{V_1 = \frac{V_o}{2}} \longrightarrow (2)$$

put (2) in (1), we get

$$2V_o = \frac{3V_o}{2} + 6 \Rightarrow \frac{V_o}{2} = 6 \Rightarrow \boxed{V_o = 12V}$$

2) A) $I_c = I_1$




$$\Rightarrow \frac{C\, dV_c(t)}{dt} = \frac{-V_o}{100K}$$

$$\Rightarrow V_o = -10^5 * 10^{-8} * \frac{d\,\vartheta_{in}(t)}{dt}$$

$$\Rightarrow \boxed{V_o = -10^{-3} \frac{d\,\vartheta_{in}(t)}{dt}}$$

$$\left[\because \vartheta_c(t) = \vartheta_{in}(t) - 0 = \vartheta_{in}(t)\right]$$

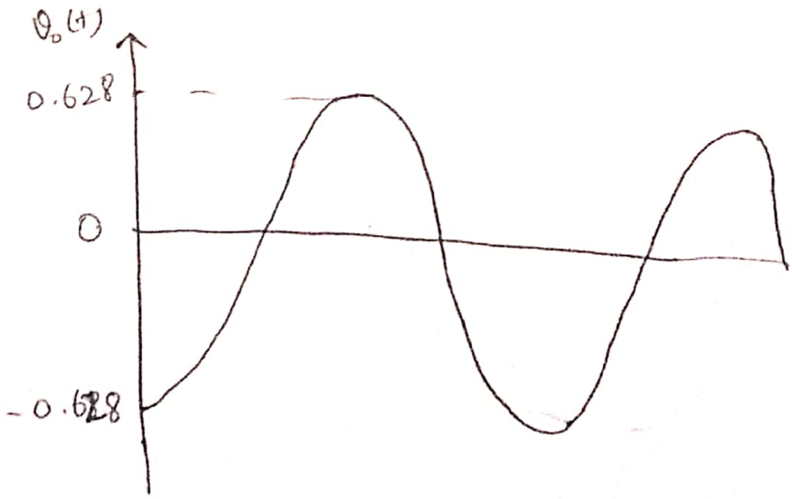
$$\vartheta_{in}(t) = 1 + \sin 2\pi \left(\frac{1}{10\times10^{-3}}\right) t$$

$$= 1 + \sin(200\pi t)$$

$$\Rightarrow \vartheta_o = -10^{-3} \frac{d}{dt}\left(1 + \sin 200\pi t\right)$$

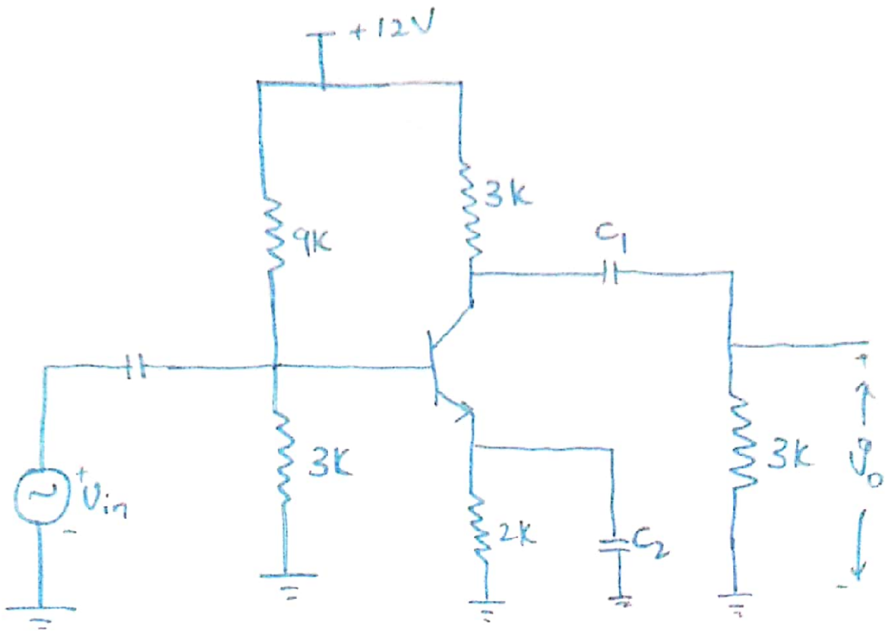
$$= -10^{-3}\left[\left(\cos(200\pi t)\right) * 200\pi\right]$$

$$\boxed{\vartheta_o = -0.628 \cos(200\pi t)}$$



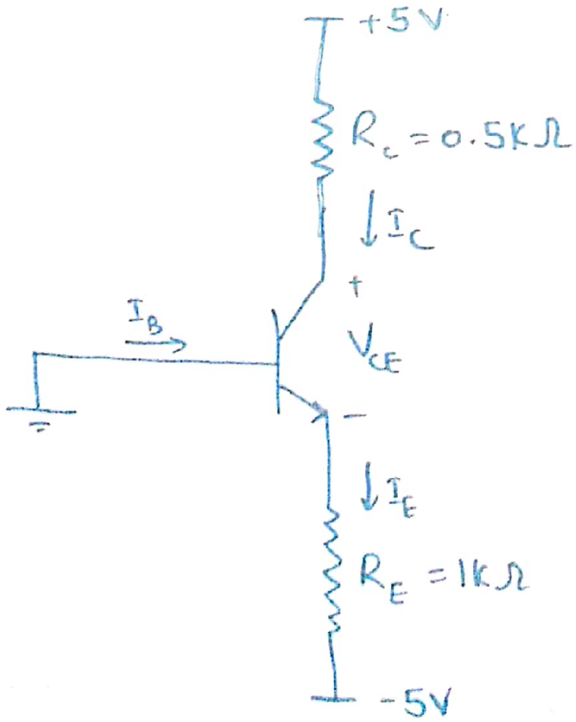
*1. For the CE Amplifier given, Calculate Voltage gain, Current gain, i/p resistance & o/p resistance if $\beta = 100$ & $V_t = 25mV$

Neglect early effect. $V_{BE(ON)} = 0.7V$




*2 Calculate the characteristics of the circuit shown below

Consider $V_{BE(ON)} = 0.65V$ & $\beta = 100$. (Draw the Load line)

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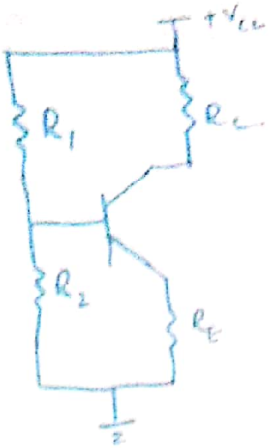
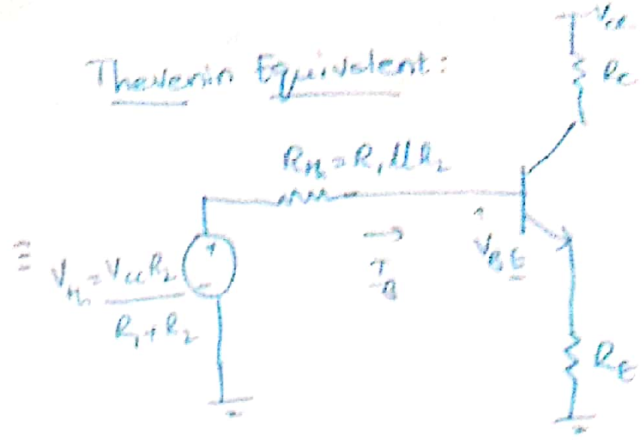
1) A)




Thevenin Equivalent:



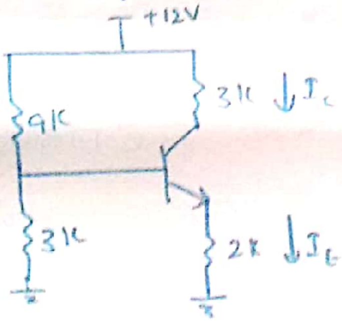

$$\Downarrow$$

$$\text{KVL} \Rightarrow V_{th} - I_B R_{th} - V_{BE} - I_E R_E = 0$$

$$\left[\because I_B = \frac{I_E}{\beta+1}\right]$$

$$\Rightarrow \boxed{I_E = \frac{V_{th} - V_{BE}}{R_E + \frac{R_{th}}{\beta+1}}}$$

DC Analysis: O.C capacitors



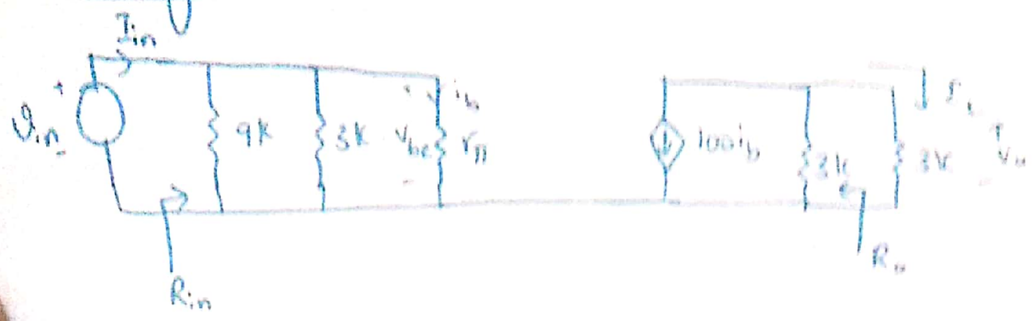

$$I_E = \frac{\frac{12(3K)}{12K} - 0.7}{2K + \frac{(3K)(9K)}{(12K)(101)}} = 1.137\text{mA}$$

$$\Rightarrow I_c = \left(\frac{\beta}{\beta+1}\right) I_E = 1.126\text{mA}$$

$$g_m = \boxed{\frac{I_c}{V_t}} = \frac{1.126}{25}$$

$$\Rightarrow r_\pi = \boxed{\frac{\beta}{g_m}} = \frac{100}{\frac{1.126}{25}} = 2220.24$$

AC- Analysis: S.C Capacitors




I/p Resistance:

$R_{in} = 9K \parallel 3K \parallel 2.22K$

$\Rightarrow \boxed{R_{in} = 1.17 K\Omega}$

o/p resistance:

S.C i/p source i.e, $V_{in} = 0$

$\Rightarrow V_{in} = i_b * r_\pi \Rightarrow i_b = 0$

$\Rightarrow 100 i_b$ source will be O.C

$\Rightarrow \boxed{R_o = 3 K\Omega}$

Voltage gain:

$V_{be} = V_{in}$

$\Rightarrow V_{be} = i_b * r_\pi$

$\Rightarrow V_{in} = i_b * 2.22K.$

$i_b = \frac{V_{in}}{2.22K}$

$V_o = -100 i_b [3K \parallel 3K]$

$= \frac{-100 * V_{in}}{2.22K} [1.5K]$

$\Rightarrow \boxed{A_V = \boxed{\frac{V_o}{V_{in}}} = -67.5}$

Current gain:

$9K \parallel 3K = 2.25 K\Omega$

$i_b = \frac{I_{in}(2.25K)}{2.25K + 2.22K}$

$I_L = \frac{-100 i_b * 3K}{3K + 3K} = -50 i_b$

$A_I = \boxed{\frac{I_L}{I_{in}}} = \frac{I_L}{i_b} * \frac{i_b}{I_{in}}$

$= -50 * \frac{2.25K}{4.47K}$

$\boxed{A_I = -25.16}$

2) A) KVL

$$0 - V_{BE} - I_E R_E + 5 = 0$$

$$\Rightarrow I_E = \frac{5 - 0.65}{1k} = 4.35\,mA$$

$$I_B = \frac{I_E}{\beta+1} = \frac{4.35}{101} = 43.1\,\mu A$$

$$I_C = \left(\frac{\beta}{\beta+1}\right) I_E = 4.31\,mA$$

KVL

$$5 - I_C R_C - V_{CE} - I_E R_E + 5 = 0$$

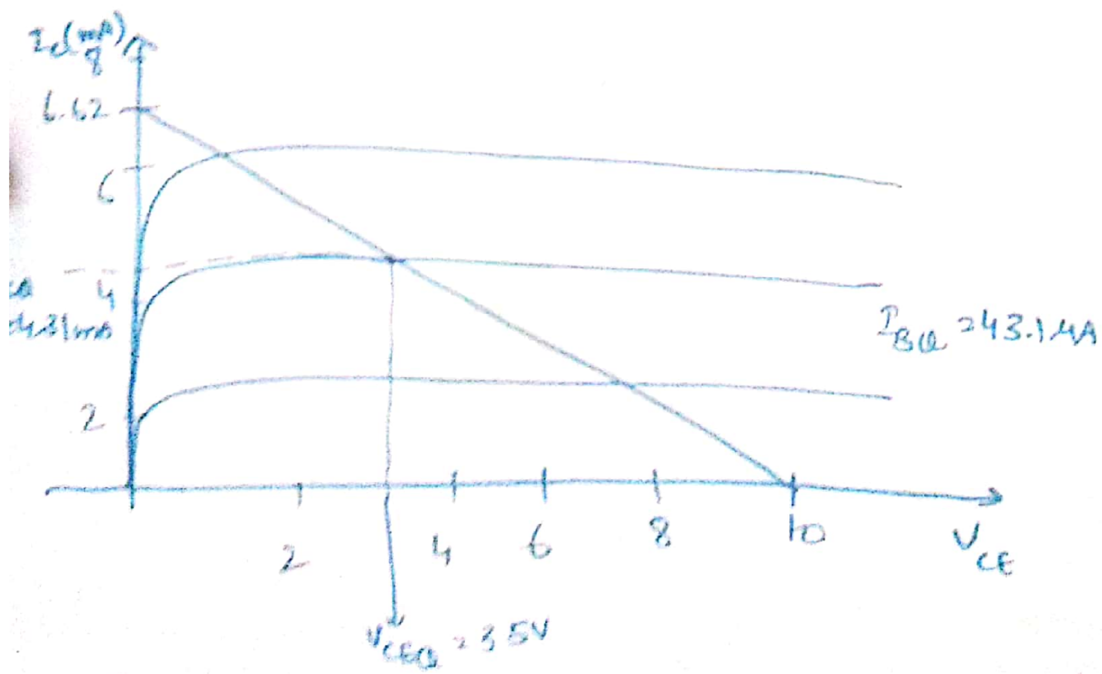
$$\Rightarrow V_{CE} = 10 - I_C R_C - I_E R_E$$

$$= 10 - (4.31)(0.5) - (4.35)(1) = 3.50V$$

Equation of load line is

$$V_{CE} = 10 - I_C\left[R_C + \left(\frac{\beta+1}{\beta}\right)R_E\right]$$

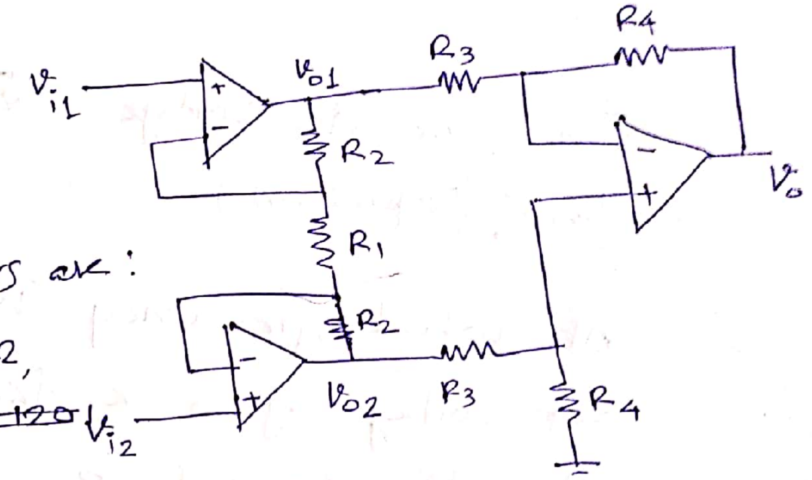
$$= 10 - 1.51 I_C$$



1)

For the instrumentation amplifier shown, the circuit parameters are:

$R_1 = 10\,K\Omega$ ; $R_2 = 40\,K\Omega$, $R_3 = 40\,K\Omega$ and ~~$R_4 = 120$~~ $R_4 = 120\,K\Omega$.




Determine $v_{o1}$, $v_{o2}$, $v_o$ and the current in $R_1$ for $v_{i1} = 1.2 - 0.08 \sin \omega t$ (V) and $v_{i2} = 1.2 + 0.08 \sin \omega t$

Ans:

$$i_1 = \frac{v_{i1} - v_{i2}}{R_1} = \frac{1.2 - 0.08 \sin \omega t - 1.2 + 0.08 \sin \omega t}{10\,K}$$

$$= \cancel{16\mu A} \; -16 \sin \omega t \; \mu A$$

$$v_{o1} = (1.2 - 0.08 \sin \omega t) + (-0.016 \sin \omega t) \times 40$$

$$= 1.2 - 0.72 \sin \omega t \; (V)$$

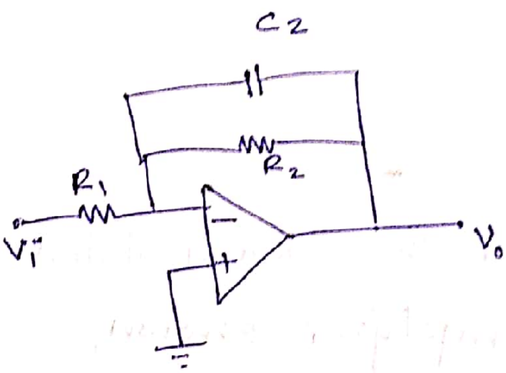
$$v_{o2} = (1.2 + 0.08 \sin \omega t) - (-0.016 \sin \omega t) \times 40$$

$$= 1.2 + 0.72 \sin \omega t \; (V)$$

$$v_o = \frac{R_4}{R_3}(v_{o2} - v_{o1}) = \frac{120}{40} \times 2 \times 0.72 \sin \omega t$$

$$= 4.32 \sin \omega t \; (V)$$

2)




Find the dc voltage gain? (expression)

At what frequency is the magnitude of the ~~vol~~ voltage gain a factor of $\sqrt{2}$ less than that of its dc value? (ie, its −3 dB frequency).

Ans:

$$\text{gain} = \frac{-Z_2}{R_1} \; ; \quad Z_2 = R_2 \parallel X_{C_2} = \frac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}}$$

$$\Rightarrow Z_2 = \frac{R_2}{1 + j\omega R_2 C_2}$$

$$\Rightarrow A_v = \frac{-R_2}{R_1} \cdot \frac{1}{1 + j\omega R_2 C_2}$$

At DC, $\omega = 0 \Rightarrow A_v = \frac{-R_2}{R_1}$

$$|A_v| = \frac{R_2}{R_1} \cdot \frac{1}{\sqrt{1 + (\omega R_2 C_2)^2}}$$

$$1 + (\omega R_2 C_2)^2 = 2 \Rightarrow \omega = \frac{1}{R_2 C_2} \Rightarrow f = \frac{1}{2\pi R_2 C_2}$$