1. Plot the output voltage (V_o) waveform for the peak detector shown below. The diode is ideal.

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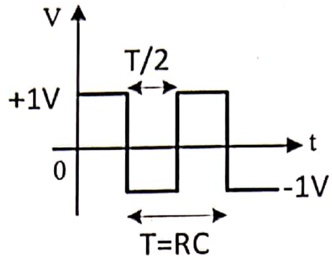
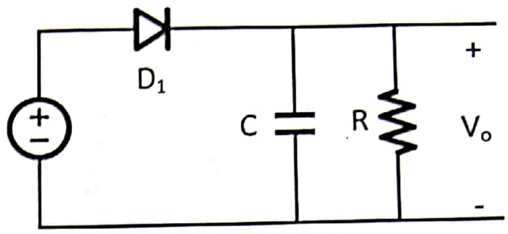
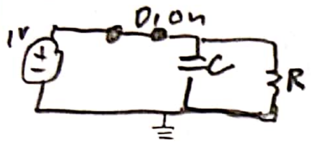


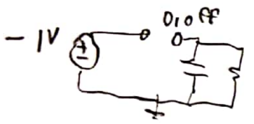


At $t=0$:



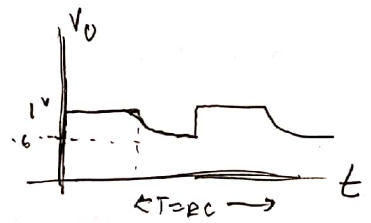
$V_o = 1V$ ✓

At $t = \frac{RC}{2}$:



$V_o = (1V)\, e^{-\frac{t - RC/2}{RC}}$ (discharging) → decays to $V_o = 1V\, e^{-\frac{RC/2}{RC}} = 0.606$ ✓

At $t = RC$: $V_o = 1V$ again and the cycles repeat.



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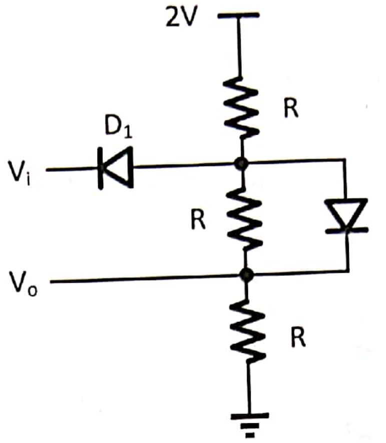
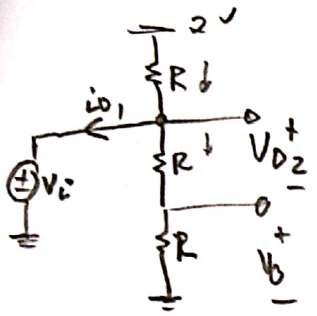
2. For the following circuit, plot the output-input characteristics. The diodes are ideal.



sweep from $V_i = -\infty$ to $+\infty$

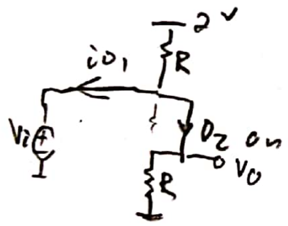
at $V_i = -\infty$, D_1 on, D_2 off



KCL: $i_{D_1} = \frac{2 - V_i}{R} - \frac{V_i}{2R} > 0$ ✓ turns off at $V_i = 4/3^V$ ✓ ← $2 - 3/2\, V_i = 0$

voltage divider → $V_{D_2} = \frac{V_i}{2} < 0$ turns on at $V_i \geq 0^V$ and $V_o = \frac{V_i}{2}$

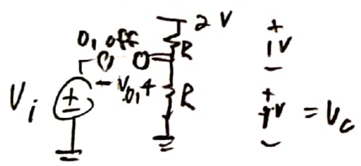
D_2 turns on first: (at $V_i \geq 0^V$)



$i_{D_1} = \frac{2 - V_i}{R} - \frac{V_i}{R} > 0$ ✓ check $i_{D_2} = \frac{V_i}{R} > 0$ ✓

D_1 turns off when $V_i = 1^V$ and $V_o = V_i$

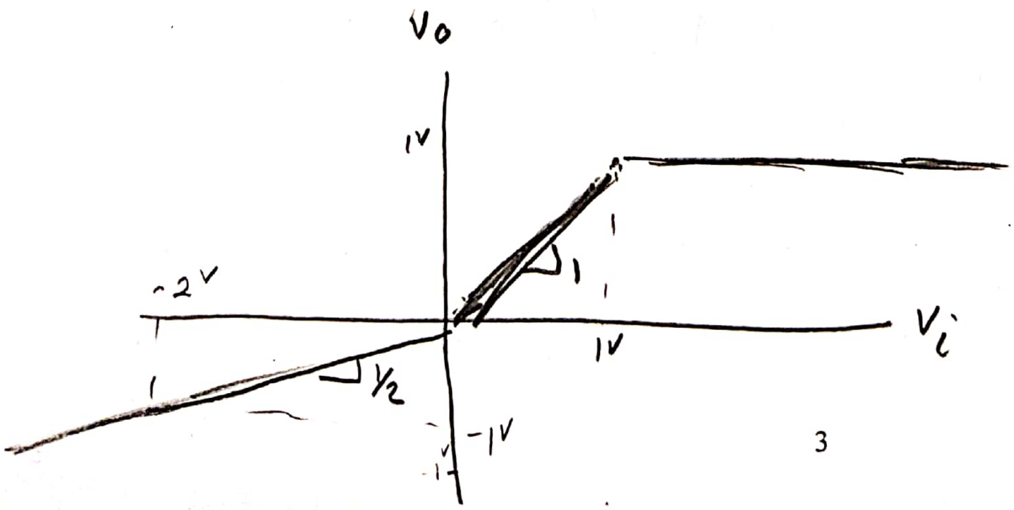
at $V_i > 1^V$:



voltage divider: $V_o = 2^V\left(\frac{R}{2R}\right) = 1^V$

$i_{D_2} = 1^V \cdot R > 0$ ✓ remains: on

$V_{D_1} = -V_i < 0$ ✓ off



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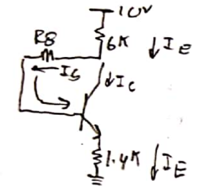
use $\frac{kT}{q} = 25mV$

3. A self-biased CE amplifier is shown below.
   a. Find the transistor DC operating points. Check what region of operation the transistor is biased at.
   b. Calculate the small signal voltage gain $\frac{v_o}{v_s}$, and the input impedance of the amplifier, R_{in}. The resistor R_B may be ignored.
   c. Calculate the small signal voltage gain $\frac{v_o}{v_s}$ without ignoring R_B.

$V_{BE,ON} = 0.6V$, $\beta = 100$, and $V_A = \infty$.

Assume FA.

a) DC analysis:



KVL: $10^V = 6^K I_E + 202k\, I_b + V_{BE,on} + 1.4k\, I_e$

$10^V - 0.6 = 7.4^K (\beta+1) I_b + 202k \cdot I_b$

$\frac{9.4^V}{(7.4^K)(101) + 202^K} = I_b$

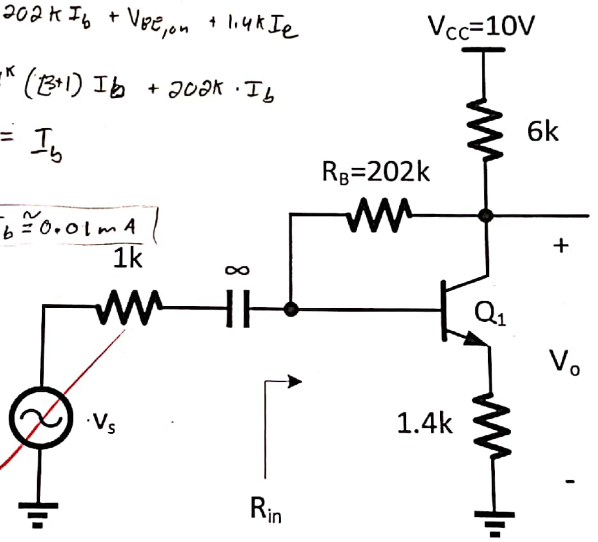
$I_b = 0.0099\ mA \simeq$ $I_b \cong 0.01\,mA$

$I_e = (\beta+1) I_b \rightarrow$ $I_e \cong 1mA$

$I_c = \beta I_b \rightarrow$ $I_c = 0.99\,mA$

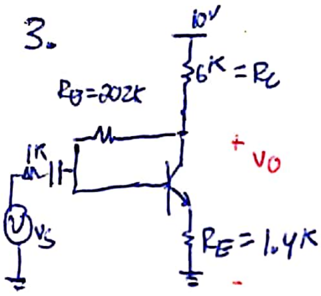
$V_{CE} = 10^V - 6K \cdot I_E \Rightarrow$ $V_{CE} = 4^V$

$V_{CE} = 4^V > V_{CE,sat}$ ✓ forward Active Mode.



Problem 3b,c on attached paper.

3.



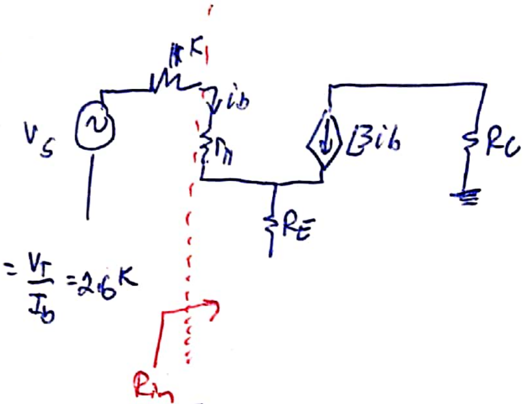
a) OC:

$(I_b + I_c)R + I_B R_B + V_{BE(on)} + I_E R_E = 10^V$

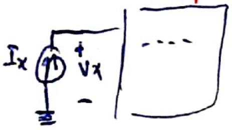
$I_C \cong 1mA$ $\qquad$ $I_B = \frac{I_C}{\beta}$

FA region ✓

b)



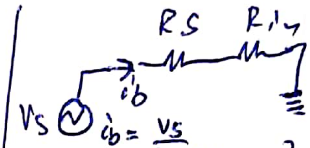
$r_\pi = \frac{V_T}{I_b} = 2.6K$



$I_x = i_b$

$V_x = (1+\beta) i_b R_E + i_b r_\pi$

$R_{in} = \frac{V_x}{I_x} = (1+\beta)R_E + r_\pi = 144K$

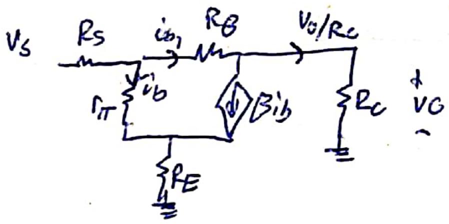


$i_b = \frac{V_S}{R_S + R_{in}}$

$V_o = -\beta i_b R_C$

$\frac{V_o}{V_S} = \frac{\beta R_C}{R_{in} + R_S} = \boxed{-4.1}$

c)



$i_{b_1} = \beta i_b + V_o / R_C$

outer loop:

$V_S = R_S(i_b + i_{b_1}) + R_B i_{b_1} + V_o$

left loop:

$V_S = R_S(i_b + i_{b_1}) + i_b r_\pi + (1+\beta) i_b R_E$

$$\boxed{\frac{V_o}{V_S} = -3.9}$$

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