Texas A&M University
Department of Electrical and Computer Engineering

ECEN 325 – Electronics

Fall 2025

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are **6** pages in your exam
- Good Luck!

Problem	Score	Max Score
1		10
2		20
3		35
4		35
Total		**100**

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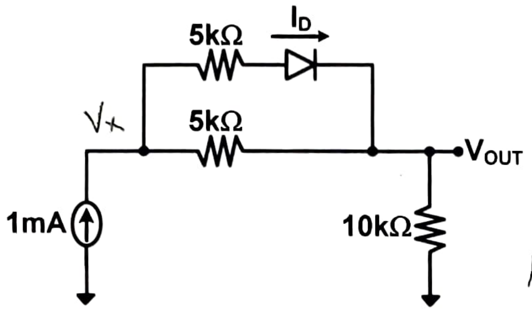
Problem 1 (10 points)

For all the circuits below, use the constant-voltage-drop diode model (V_D=0.7V), V_{th}=25.9mV, and n=1.

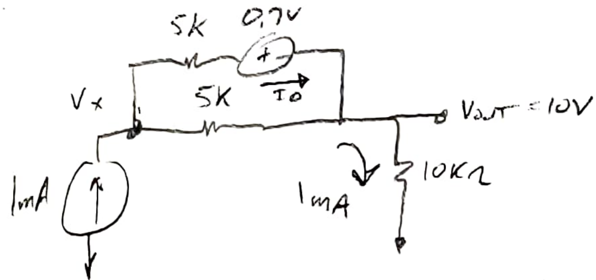
a) Find V_{OUT}, I_D, and the small signal diode resistance, r_d.



If Diode is off ⇒ $V_{OUT} = 10V$, $V_X = 15V$

$V_D = 5V$ ⇒ Not consistent

Diode must be forward-biased w/ $V_D = 0.7V$



KCL @ Vx

$$-1mA + \frac{V_X - 10}{5K} + \frac{V_X - 10.7}{5K} = 0$$

$$2V_X = 25.7V$$

$$V_X = 12.85V$$

$$I_D = \frac{12.85V - 10.7V}{5K\Omega} = 430\mu A$$

$$r_d = \frac{V_{th}}{I_D} = \frac{25.9mV}{430\mu A} = 60.2\Omega$$

V_{OUT} = 10V

I_D = 430μA

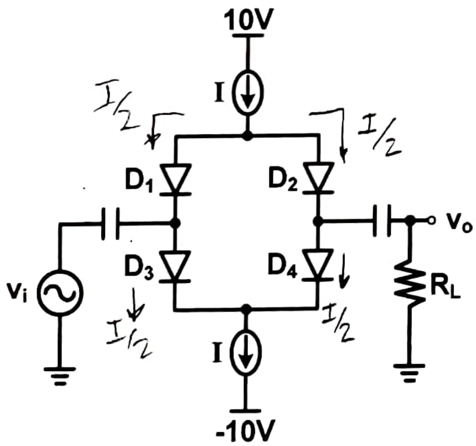
r_d = 60.2Ω

Problem 2 (20 points)

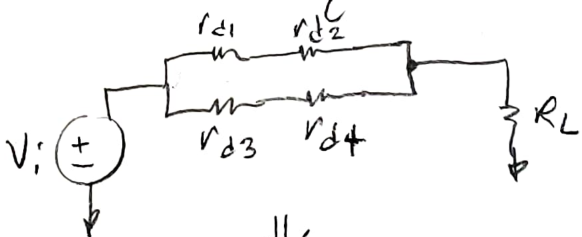
Assume for the following circuit that **all diodes are forward biased with equal DC current** and the capacitors act as AC shorts. $V_{th} = 25.9mV$, $n = 1$

a) Derive an expression for the small-signal gain A_v=v_o/v_i. ~~(10 points)~~

b) Assuming R_L=100Ω, calculate the value of I for A_v=0.8 ~~(10 points)~~



AC Equivalent Circuit



⇓

$$\frac{V_o}{V_i} = \frac{R_L}{r_d + R_L}$$

$$r_d = \frac{V_{th}}{I/2}$$

$$\frac{R_L}{\frac{2V_{th}}{I} + R_L} = 0.8$$

A_v Expression = $\frac{R_L}{r_d + R_L}$

I (A_v=0.8) = 2.07mA

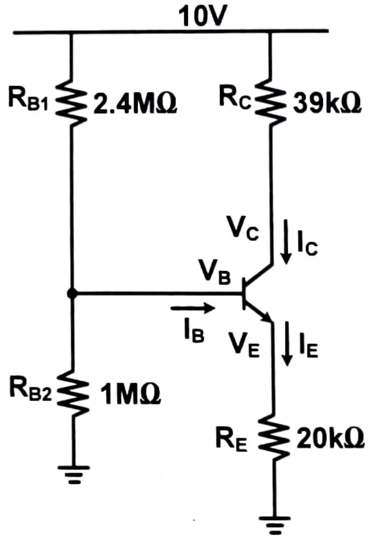
$$I = \frac{2V_{th}}{\frac{R_L}{0.8} - R_L} = \frac{2(25.9mV)}{\frac{100}{0.8} - 100} = 2.07mA$$

Problem 3 (35 points)

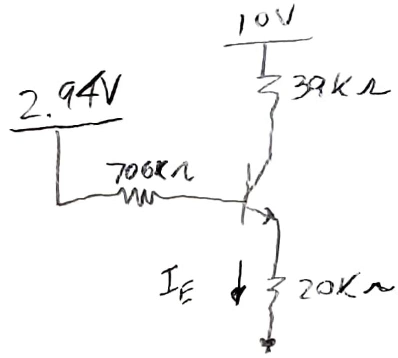
Assume for Problem 2 that the transistor β=150, V_{BE}=0.7V, and V_{th}=25.9mV.

a) Calculate the DC values for V_C, V_B, V_E, I_C, I_B, and I_E. Compute the AC small signal parameters g_m, r_π, r_e. (25 points)

b) Give the maximum value of R_C such that the transistor remains in the active mode with a minimum V_{CE}=300mV. (10 points)



Thevenin Eq Circuit



I_C = 90.2μA

I_B = 0.6μA

I_E = 90.8μA

V_C = 6.48V

V_B = 2.52V

V_E = 1.82V

g_m = 3.48 mA/V

r_π = 43.2KΩ

r_e = 285Ω

Max R_C (Active Mode) = 87.4KΩ

$$I_E = \frac{2.94V - 0.7V}{20k + \frac{706K}{151}} = 90.8\mu A$$

$$I_B = \frac{I_E}{\beta+1} = \frac{90.8\mu A}{151} = 0.6\mu A$$

$$V_E = I_E R_E = 90.8\mu A(20K) = 1.82V$$

$$I_C = \beta I_B = 150(0.6\mu A) = 90.2\mu A$$

$$V_B = V_E + 0.7V = 2.52V$$

$$g_m = \frac{I_C}{V_{th}} = \frac{90.2\mu A}{25.9mV} = 3.48\,mA/V$$

$$V_C = V_{CC} - I_C R_C = 10V - 90.2\mu(39K) = 6.48V$$

$$r_\pi = \frac{V_{th}}{I_B} = \frac{25.9mV}{0.6\mu A} = 43.2K\Omega$$

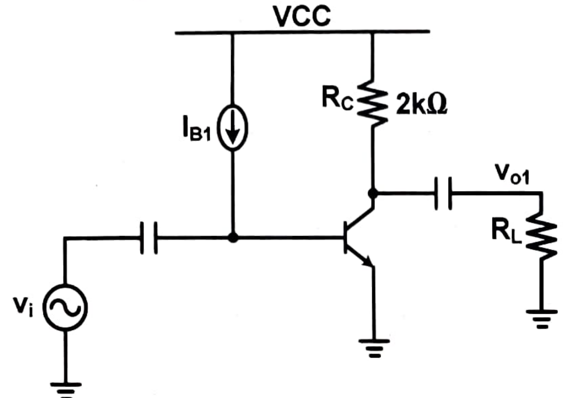
$$r_e = \frac{V_{th}}{I_E} = \frac{25.9mV}{90.8\mu A} = 285\Omega$$

Max R_C: Min $V_C = V_E + 0.3V = 2.12V$

$$V_C = V_{CC} - I_C R_C \Rightarrow R_C = \frac{V_{CC} - V_C}{I_C} = \frac{10V - 2.12V}{90.2\mu A} = 87.4K\Omega$$

Problem 4 (35 points)

a) For the following amplifier, assume the transistor β=150, $r_o=\infty$, and that the transistor is biased such that g_m=50mA/V, r_e=19.8Ω, and r_π=3kΩ. Calculate the amplifier gain, $A_{v1}=v_{o1}/v_i$, for two load resistor conditions: $R_L=\infty$ and R_L=50Ω. Recall that an ideal current source has infinite output resistance, ie $R_B=\infty$. Assume that the capacitors act as AC shorts. (6 points)



$A_V = -g_m(R_C \| R_L)$

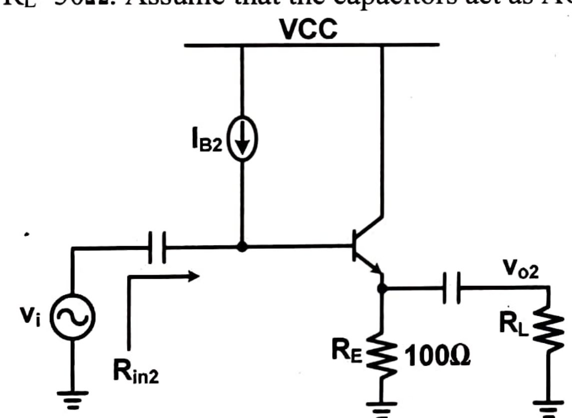
w/ $R_L=\infty$: $-50\,mA/V\,(2K) = -100$

w/ $R_L=50$: $-50\,mA/V\,(2K \| 50) = -2.44$

A_{v1} ($R_L=\infty$) = −100 V/V

A_{v1} (R_L=50Ω) = −2.44 V/V

b) For the following amplifier, assume the same transistor bias conditions: β=150, $r_o=\infty$, and that the transistor is biased such that g_m=1.16A/V, r_e=0.86Ω, and r_π=130Ω. Calculate the amplifier gain, $A_{v2}=v_{o2}/v_i$, and the input resistance, R_{in2}, for two load resistor conditions: $R_L=\infty$ and R_L=50Ω. Assume that the capacitors act as AC shorts. (14 points)



$A_V = \frac{R_E \| R_L}{r_e + R_E \| R_L}$

w/ $R_L=\infty$ $A_V = \frac{100}{0.86+100} = 0.991$

w/ $R_L=50$ $A_V = \frac{100\|50}{0.86+100\|50} = 0.975$

A_{v2} ($R_L=\infty$) = 0.991 V/V

A_{v2} (R_L=50Ω) = 0.975 V/V

R_{in2} ($R_L=\infty$) = 15.2 KΩ

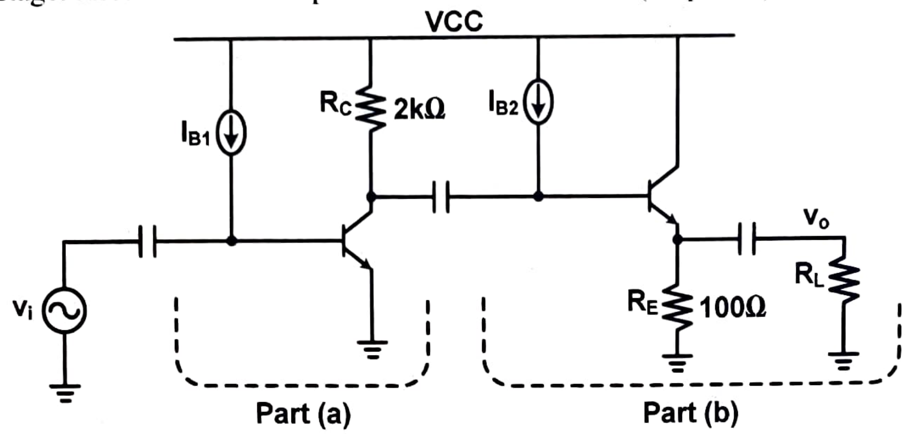
R_{in2} (R_L=50Ω) = 5.16 KΩ

$R_{in} = r_\pi + (\beta+1)(R_E \| R_L)$

w/ $R_L=\infty$ $130 + 151(100) = 15.2K\Omega$

w/ $R_L=50$ $130 + 151(100\|50) = 5.16k\Omega$

c) The circuit below consists of the amplifier from part (a) cascaded with the amplifier from part (b). Calculate the total 2-stage amplifier gain, $A_v=v_o/v_i$, for two load resistor conditions: $R_L=\infty$ and $R_L=50\Omega$. Remember to consider the loading of the second stage input resistance on the first stage. Assume that the capacitors act as AC shorts. (15 points)



A_v ($R_L=\infty$) = -87.6 V/V

A_v ($R_L=50\Omega$) = -70.3 V/V

$$A_V = -g_{m1}(R_C \| R_{in2}) \frac{R_E \| R_L}{r_e + R_E \| R_L}$$

w/ $R_L=\infty$ $\quad -50\,mA/V(2k \| 15.2k)(0.991) = -87.6$

w/ $R_L=50$ $\quad -50\,mA/V(2k \| 5.16k)(0.975) = -70.3$