Habib University

Electrical Engineering Department

Dhanani School of Science & Engineering

Course	EE – 211 – Basic Electronics
Semester	Fall 2022
Section	Section L2
Exam	Midterm Exam – 2
Instructor	Dr. Ahmad Usman
Total Marks	25

Name: SOLUTION **Student ID:** _____

Note:

i. Attempt all questions.
ii. No cheat sheets or formula sheets are allowed.
iii. You can use your own calculators.
iv. There are seven printed pages in this exam booklet. Don't open staple of the booklet.

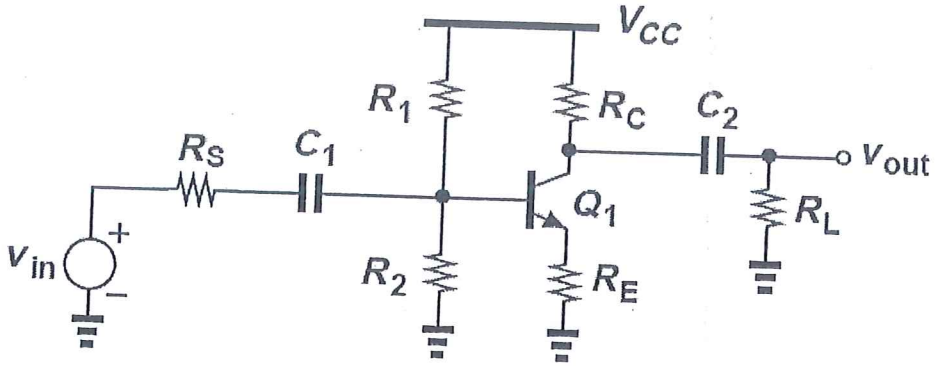
Questions	Points
Q1 (CLO – 2)	/8
Q2 (CLO – 3)	/7
Q3 (CLO – 1)	/4
Q4 (CLO – 1)	/6
Total Obtained	**/25**

Question # 1 (CLO – 2 – Points: 8, 3 + 5)

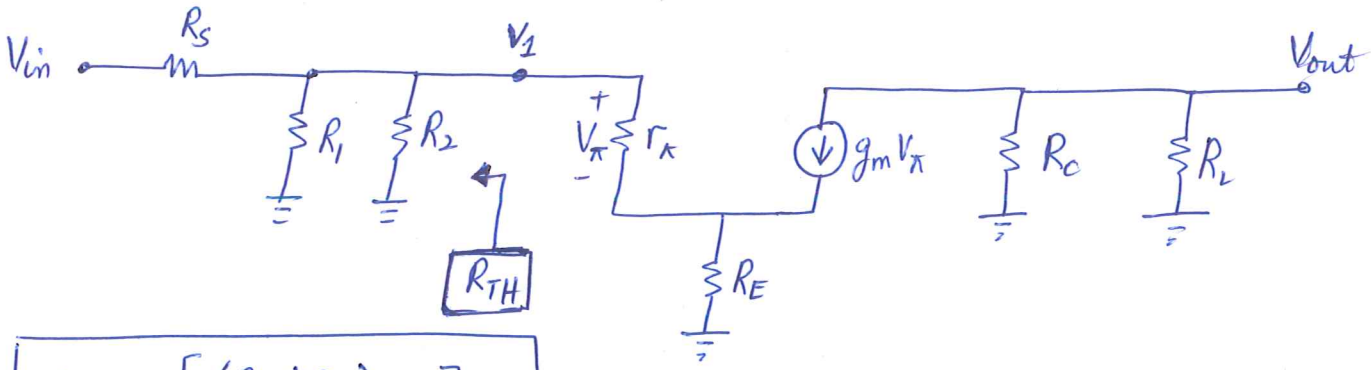
Draw the small-signal model for the circuit shown below. Also, calculate the voltage gain V_{out} / V_{in}. The specifications of the circuit are as follows:

$I_S = 8x10^{-16}$ A, $V_{CC} = 2.5V$, $V_A = \infty$, $\beta = 100$, $R_C = 10$ kΩ, $R_E = 500$ Ω, $R_1 = 14$ kΩ, $R_2 = 11$ kΩ, $R_S = 1$ kΩ, $R_L = 100$ kΩ

Assume extremely high value capacitors.



Small Signal Model



$$V_1 = \left[\frac{(R_1 // R_2)}{R_S + (R_1 // R_2)}\right] V_{in}$$

$$R_{TH} = R_S // R_1 // R_2$$

$$I_c = I_s \exp\left(\frac{V_{BE}}{V_T}\right)$$

Let $V_{BE} = 0.7V$

$V_T = 26mV$

$I_c = 394.124\mu A$

$$V_1 = \left(\frac{6.16\ K}{1K + 6.16K}\right) V_{in}$$

$$\frac{V_1}{V_{in}} = 0.86033$$

$$g_m = \frac{I_c}{V_T}$$

$g_m = 15.1586mS$

$R_{TH} = 0.86033\ K\Omega$

Input Resistance @ Emitter

$$R_{in} = \frac{r_\pi}{\beta} + R_E + \frac{R_{TH}}{\beta+1}$$

$$R_{in} = \frac{1}{g_m} + R_E + \frac{R_{TH}}{\beta+1}$$

$$R_{in} = \frac{1}{15.1586m} + 500 + \frac{0.8603K}{101}$$

$$R_{in} = 574.4869\ \Omega$$

$$\boxed{R_{in} = 574.49\ \Omega}$$

Output Resistance

$$R_{out} = R_C \,//\, R_L = \boxed{9.0909\ K\Omega}$$

$$Gain = A_v = -\left(\frac{R_1 // R_2}{R_s + R_1 // R_2}\right)\left(\frac{R_C // R_L}{\frac{1}{g_m} + R_E + \frac{R_{TH}}{\beta+1}}\right)$$

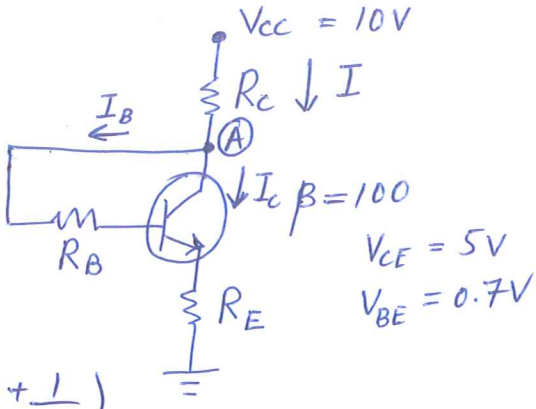
$$A_v = -(0.86033)\left(\frac{9.0909K}{574.49}\right)$$

$$\boxed{A_v = -13.614}$$

Question # 2 (CLO – 3 – Points: 7)

Design a self-bias (collector feedback bias) BJT configuration with the following specifications: $I_{C,Q} = 5$ mA, $V_{CC} = 10$V, $V_{CE,Q} = 5$V, $V_{BE} = 0.7$V, and $\beta = 100$.

Draw the circuit diagram. Determine R_C, R_E, and R_B. Assume V_E as 10% of V_{CC}.



$V_E = 10\%$ of V_{cc}

$V_E = \frac{10}{100} \times 10 = 1V$

$\boxed{V_E = I_E R_E}$

$I_E = I_c + I_B \Rightarrow I_E = (5m)\left(1 + \frac{1}{100}\right)$

$I_c = \beta I_B$

$\boxed{I_E = 5.05\,mA}$

$R_E = \frac{1}{5.05m} = \boxed{198.0198\,\Omega}$

$R_E = 198.02\Omega$
$R_c = 792.08\Omega$
$R_B = 86\,k\Omega$

Output Loop:

$V_{cc} - I R_c - V_{CE} - V_E = 0$

$10 - (5.05m) R_c - 5 - 1 = 0$

$R_c = \frac{4}{5.05m}$

$\boxed{R_c = 792.079\,\Omega}$

@ node A

$V_A = V_{CE} + V_E \quad — (1)$

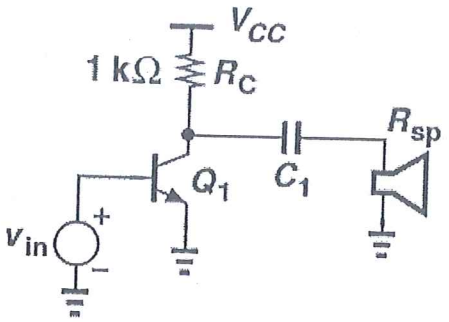
$V_A = I_B R_B + V_{BE} + I_E R_E \quad — (2)$

$I_B R_B + V_{BE} + \cancel{I_E R_E} = V_{CE} + \cancel{V_E}$

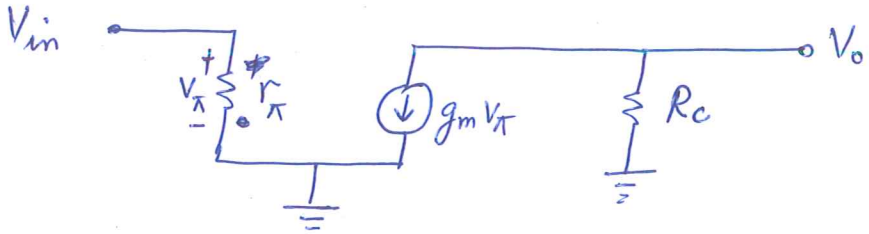
$R_B = \frac{5 - 0.7}{(5/100)\,m} = \boxed{86\,k\Omega}$

Question # 3 (CLO – 1 – Points: 4)

A CE stage exhibits a voltage gain of 20 and an output resistance of 1 kΩ. Determine the voltage gain of the CE amplifier if the stage drives an 8-Ω speaker directly. Explain in your own words what happened to the gain?



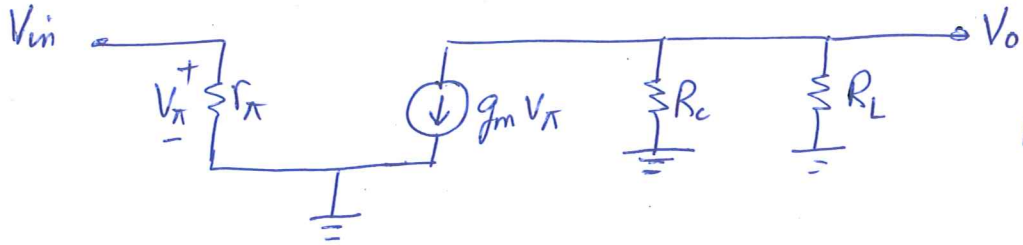
Without Speaker



$$\text{Gain} = |A_v| = |-g_m R_c|$$

$$20 = g_m (1k) \longrightarrow \boxed{g_m = 0.02\ S}$$

After Speaker



R_L = Speaker

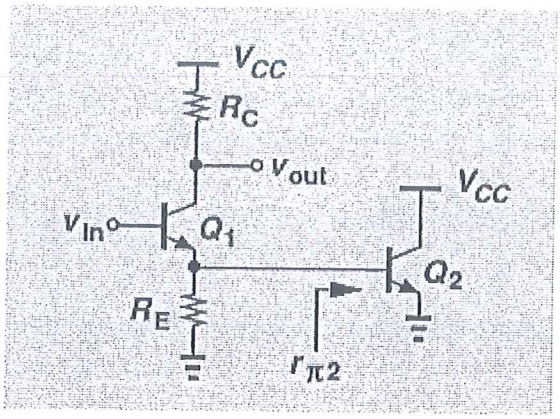
$$\text{Gain} = |A_v| = |-g_m (R_c // R_L)|$$

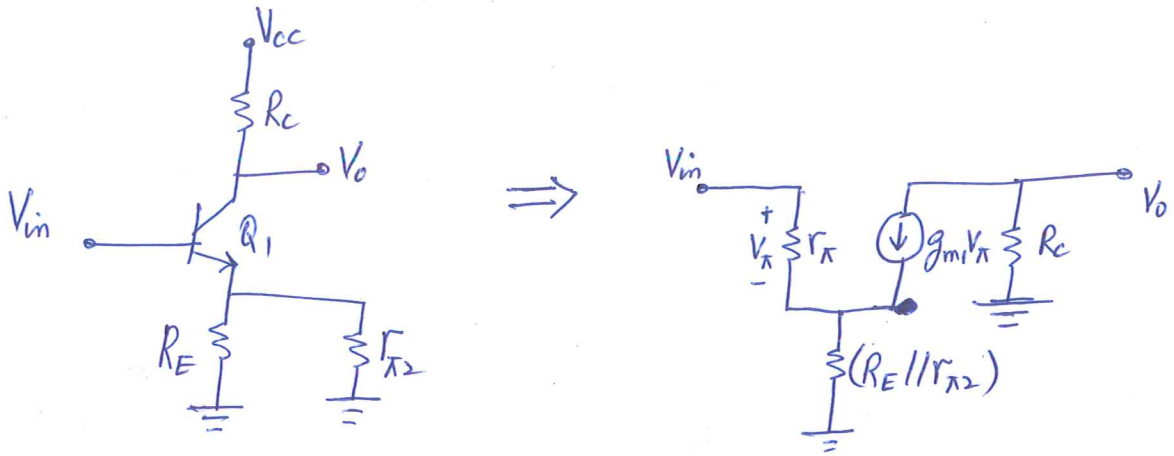
$$\boxed{A_v = 0.1587}$$

→ The gain decreases when the speaker was added as a load.

Question # 4 (CLO – 1 – Points: 6, 3 + 3)

(a) Determine the voltage gain of the stage shown in the figure below.



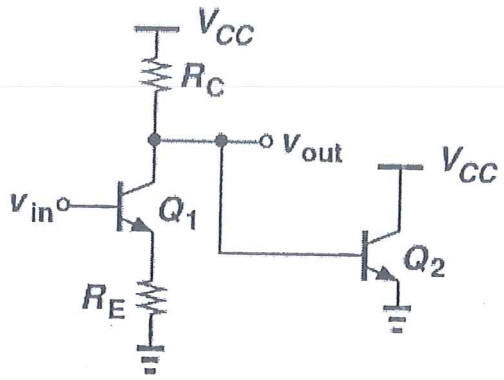


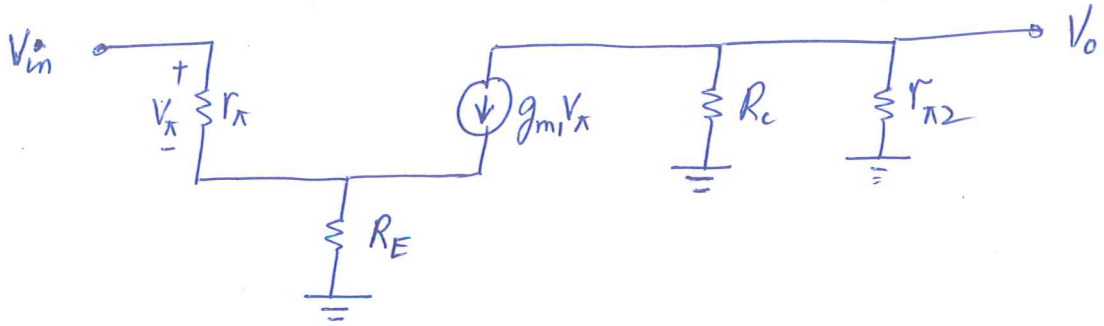
$$A_v = \frac{-g_{m1} R_C}{1 + g_{m1}(R_E // r_{\pi 2})}$$

OR

$$A_v = \frac{-R_C}{1/g_{m1} + (R_E // r_{\pi 2})}$$

(b) Determine the voltage gain of the stage shown in the figure below.





$$A_v = \frac{-g_{m1}(R_c \,//\, r_{\pi 2})}{1 + g_{m1} R_E}$$

OR

$$A_v = \frac{-(R_c \,//\, r_{\pi 2})}{1/g_{m1} + R_E}$$