Section 1

Lab Quiz #1

ECE 242: Electronic Circuits 2 (Fall 2016)
Instructor: Bosco Leung

Name:

Student ID:

Lab Session (circle one): Tuesday Wednesday Thursday

Problem 1

Circuit A and circuit B are set up as shown in Figure 1. By changing the value of the variable resistor, R_L, I_o vs V_o graph for circuit A is generated as shown in Figure 2(a) and I_o vs V_o graph for circuit B is generated as shown in Figure 2(b). The data points for figure 2 are recorded as shown in Table 1.

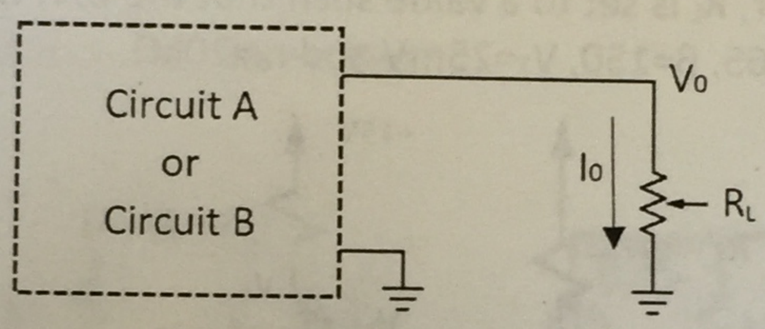
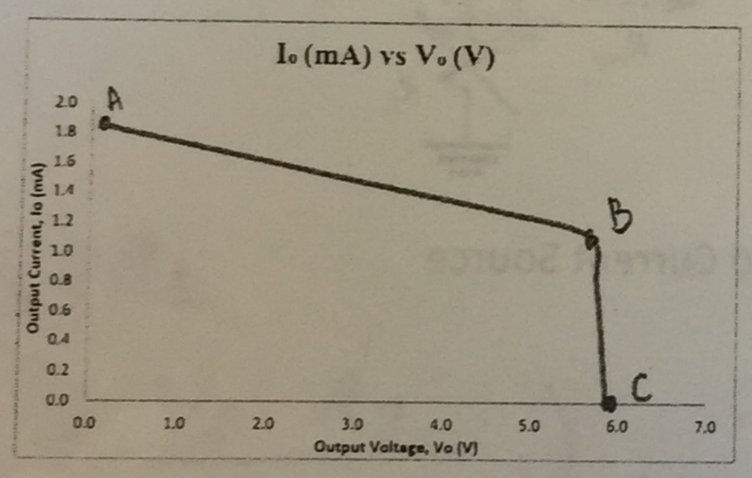
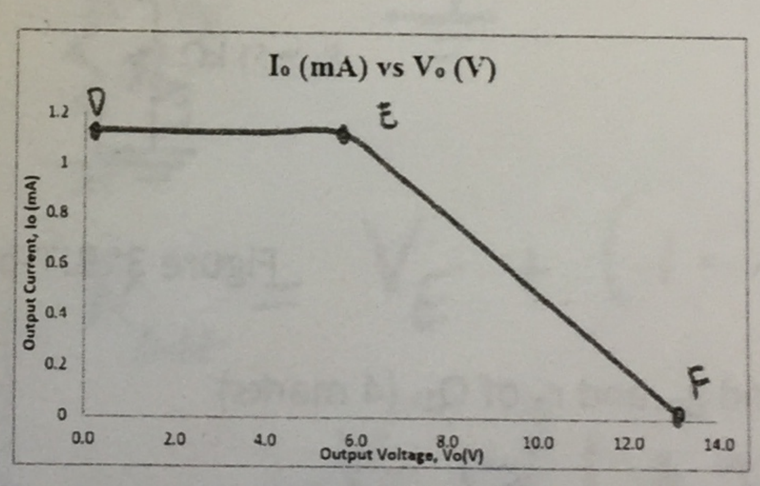


Figure 1: Laboratory Setup



(a)



(b)

Figure 2: (a) I_o vs V_o graph of circuit A. (b) I_o vs V_o graph of circuit B

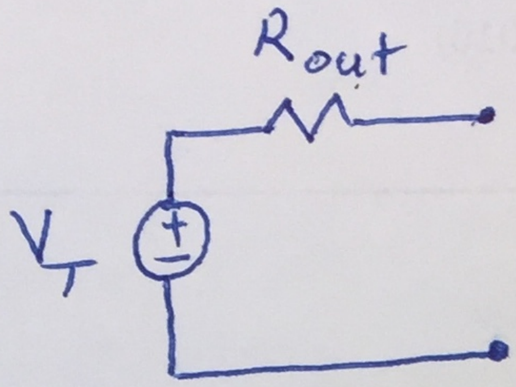
Data Points	A	B	C	D	E	F
I_o(mA)	1.83	1.19	0.0058	1.20	1.13	0.008
V_o(V)	0.025	5.70	5.86	0.022	5.85	13.4

Table 1: Data Points

a) Which circuit is a better voltage source? Justify your answer. (2 marks)

Circuit "A". circuit "A" has smaller output resistance

b) Draw a Norton or Thevenin (whichever appropriate) equivalent model for the circuit chosen in part (a). Label all components. (3 marks)



$V_T = 5.86$

$R_{out} = 135\ \Omega$

Problem 2

In Figure 3, the variable resistor, R_L is set to a value such that the BJT, Q_1 operates in forward active region. It is given that $|V_{be}|=0.65$, $\beta=150$, $V_T=25mV$ and $r_o=20k\Omega$.

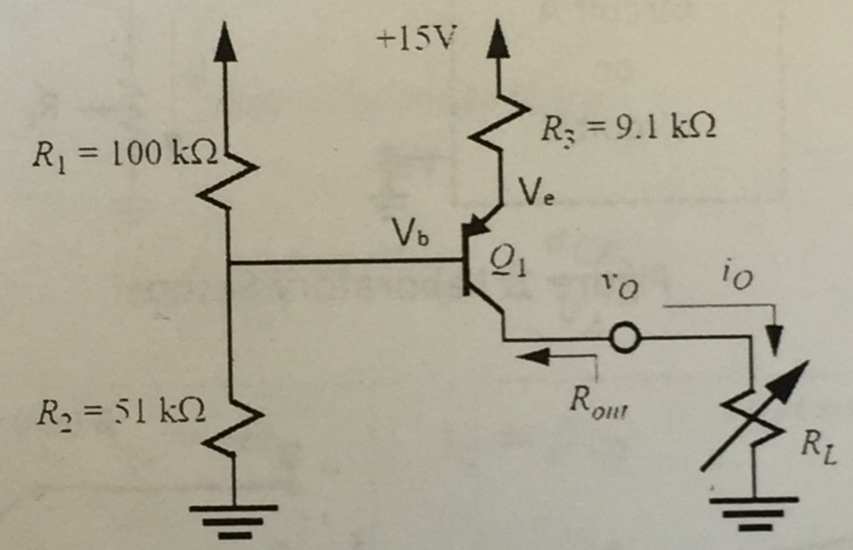


Figure 3: BJT-based Current Source

(a) Find g_m and r_π of Q_1. (4 marks)

$$V_b = \frac{51}{51+100}(15) = 5.06\ V$$

$$V_e = 5.06 + 0.65 = 5.71\ V$$

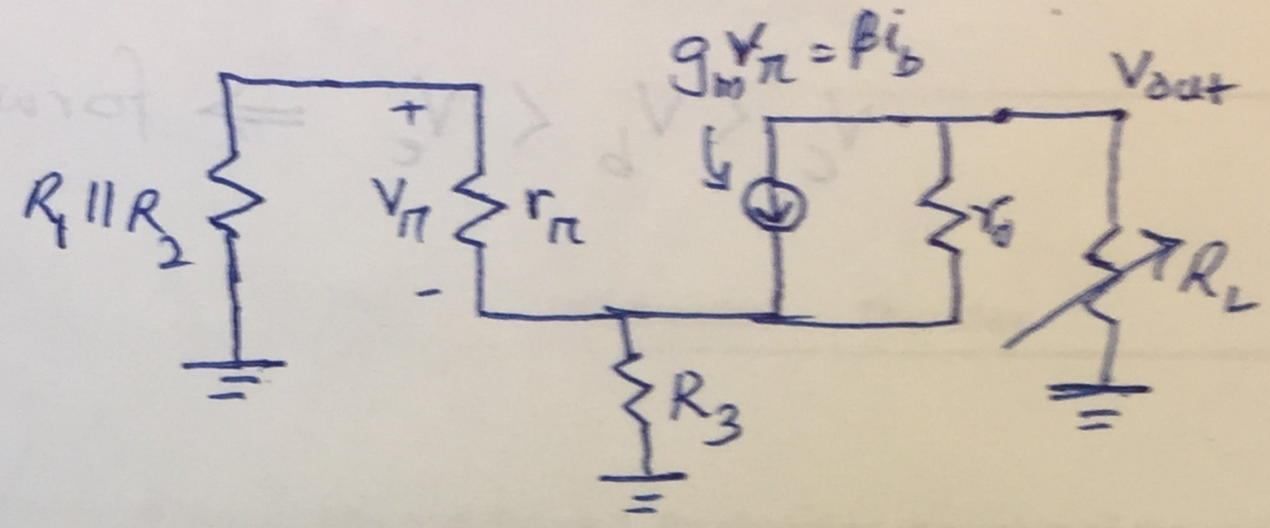
$$I_E = \frac{15 - V_e}{R_3} = \frac{15 - 5.71}{9.1\ K} = 1.02\ mA$$

$$I_{C_1} = \frac{150}{151}(1.02\ m) = 1.013\ mA$$

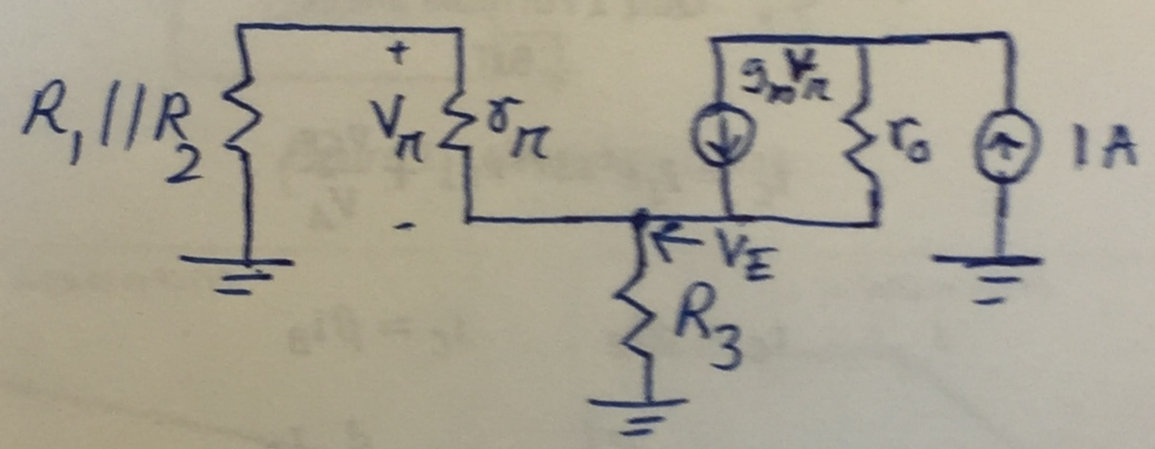
$$\therefore g_m = \frac{1.013\ m}{25\ m} = 0.0405\ A/V$$

$$r_\pi = \frac{\beta}{g_m} = \frac{150}{0.0405} = 3.703\ K\Omega$$

(b) Draw the small signal model for the circuit in Figure 3. Label all components. (3 marks)



c) Find the output resistance, R_{out}. (6 marks)



$$V_E = (1 - i_b) R_3$$

$$= \left(R_3 - \frac{V_E \; R_3}{r_\pi + R_1 \| R_2} \right)$$

$$V_E \left(1 + \frac{R_3}{r_\pi + R_1 \| R_2}\right) = R_3$$

$$\therefore V_E = \frac{R_3}{1 + \left(\frac{R_3}{r_\pi + R_1 \| R_2} \right)}$$

$$V_E = \frac{9.1\,k}{1 + \left(\frac{9.1\,k}{3.705k + (100k \| 51k)} \right)}$$

$$V_E = 7.322\ kV$$

$$R_{out} = V_E + (1 - g_m V_\pi) r_o$$

$$= V_E + \left(1 + g_m \frac{r_\pi \; V_E}{r_\pi + R_1 \| R_2}\right) r_o$$

$$= r_o + \left(1 + \frac{g_m \, r_\pi \, r_o}{r_\pi + R_1 \| R_2}\right) V_E$$

$$R_{out} = 20k + \left(1 + \frac{(150)(20k)}{3.703k + (100k \| 50k)}\right) * (7.322\,k)$$

$$\therefore R_{out} = 0.823\ M\Omega$$

d) What is the region of operation for BJT, Q_1 when R_L is set to 3kΩ. Justify your answer. (2 marks)

When $R_1 = 3k\Omega$; $V_b = 1.03m \times 3k = 3.03V$

$V_c < V_b < V_e \Rightarrow$ forward active

Quiz 1 Formula Sheet

BJT

$$i_C = I_S e^{v_{BE}/V_T}\left(1 + \frac{v_{CE}}{V_A}\right)$$

$$i_C = \alpha i_E \qquad i_C = \beta i_B$$

$$\alpha = \frac{\beta}{\beta + 1} \qquad g_m = \frac{I_C}{V_T}$$

$$r_o = \frac{V_A}{I_C}$$

$$r_\pi = \frac{V_T}{I_B} = \frac{\beta}{g_m} = (\beta + 1) r_e$$

$$r_e = \frac{V_T}{I_E} = \frac{\alpha}{g_m}$$