Electronics
EECE2412 — Spring 2016
Exam #2

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File:12140/exams/exam2

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Name: Solutions : Row # 0 : Seat # 1

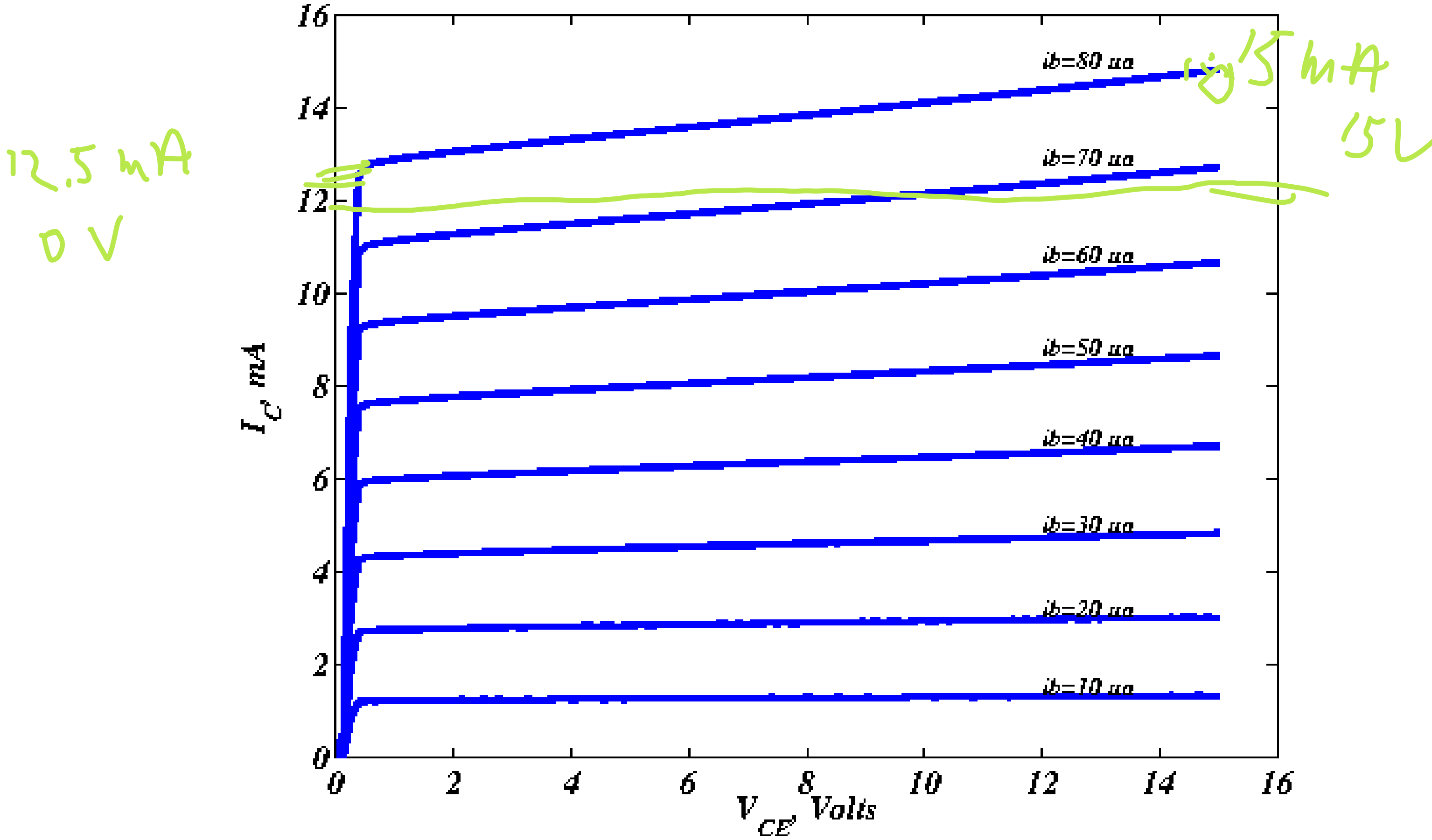
General Rules:

- Write your name, row number, and seat number above. Row #1 is at the front. Seat #1 is to the left as viewed by the students.
- You may make use of two sheets of notes, 8.5–by–11 inches, using both sides of the page.
- You may use a calculator.
- Present your work as clearly as possible. I give partial credit if I can figure out that you know what you are doing. I do not give credit for putting down everything you know and hoping I will find something correct in it.
- Each question has a vertical black bar providing space for your work and a box for numerical answers. Please write your answer to each question clearly. If it happens to be correct, I give you points quickly and move on to the next problem. Please show your work in the space provided, or on extra pages, clearly labeled with the problem number. If the answer is wrong, this will make it easy for me to find ways to give you partial credit.
- Avoid any appearance of academic dishonesty. Do not talk to other students during the exam. Keep phones, computers, and other electronic devices other than calculators secured and out of reach.

1 BJT Basics (30%)

The figure shows the characteristic curves for a Bipolar Junction Transistor.

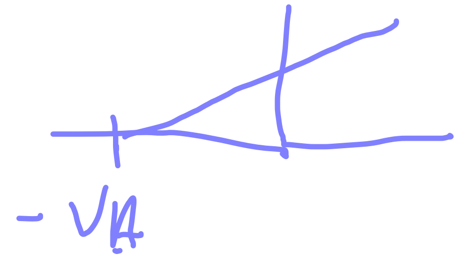
answers may vary some because of measurement errors.



1.1 DC Parameters

Determine graphically β and the Early Voltage, V_A.

$\frac{12 \text{ mA}}{80 \mu A} = 150$



$\frac{15 - 12.5 \text{ mA}}{15 - 0 \text{ V}} = 1.67 \times 10^{-4} \frac{A}{V} = \text{Slope}$

$V_A = \frac{12.5 \text{ mA}}{\text{Slope}}$

Beta: 150

Early Voltage: 75 Volts

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1.2 Small–Signal Model

Now, assume that we build a DC circuit to bias the transistor at 8 mA and 8 V. Find the small–signal parameters.

$g_m = \frac{I_c}{V_T} = \frac{8 \text{ mA}}{25 \text{ mV}} = 0.32 \text{ A/V}$

$r_\pi = \beta / g_m = 469 \, \Omega$

$r_o = \frac{V_A}{I_o} = \frac{75 \text{V}}{8 \text{mA}} = 9375 \, \Omega$

Transconductance, g_m: 320 mA/V

r_π: 469 Ohms

$r_{0)}$: 9.4 k Ohms

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2 BJT Amplifier Circuit (40%)

The figure shows a BJT amplifier circuit. The transistor has $\beta = 100$ and the Early Voltage is infinite.

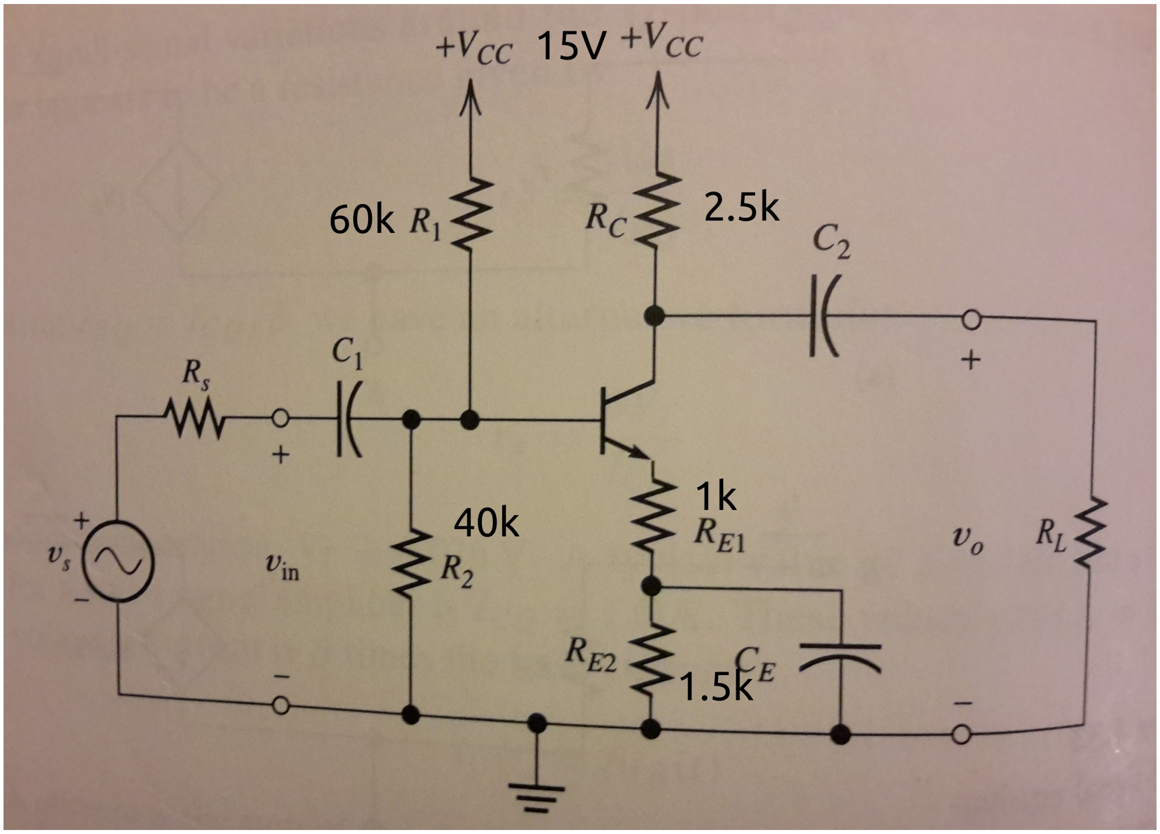

Figure from Hambley, *Electronics, 2nd Ed.*

2.1 Basics

What type of transistor is this? Circle one: (NPN) (PNP)

What type of amplifier is this? Circle one:

(Common Emitter) (Common Base) (Common Collector)

What is the main function of this type of amplifier? Circle one:

(High Gain) ($A_v = 1$) ($A_i = 1$)

3
3
3

2.2 Bias

40k || 60k = 24k

Compute the DC currents and voltages and fill in the blanks.

Base equivalent

$\frac{6V - 0.7V}{24k + 101 \times 2.5k} = 21\mu A$

$I_C = \beta I_B$

$I_E = (\beta + 1) I_B$

$V_E = I_E R_E = 2.1mA \times 2.5k\Omega = 5.25V$

$V_C = 15V - I_C R_C = 15V - 2.1mA \times 2.5k\Omega = 10.75V$

$V_B = V_E + 0.7V = 5.95V$

Collector Voltage, V_C: 10.75 Volts

Emitter Voltage, V_E: 5.25 Volts

Base Voltage, V_B: 5.95 Volts

Collector Current, I_C: 2.1 mA

Emitter Current, I_E: 2.121 mA

Base Current, I_B: 21 μA

3 points each

$g_m = \frac{I_C}{V_T} = \frac{2.1mA}{25mV} = 0.084\frac{A}{V}$

$r_\pi = \frac{\beta}{g_m} = 1190\Omega$

What are the transconductance and $_r\pi$?

$g_m =$ 84 mA/V

$r_\pi =$ 1190 Ohms

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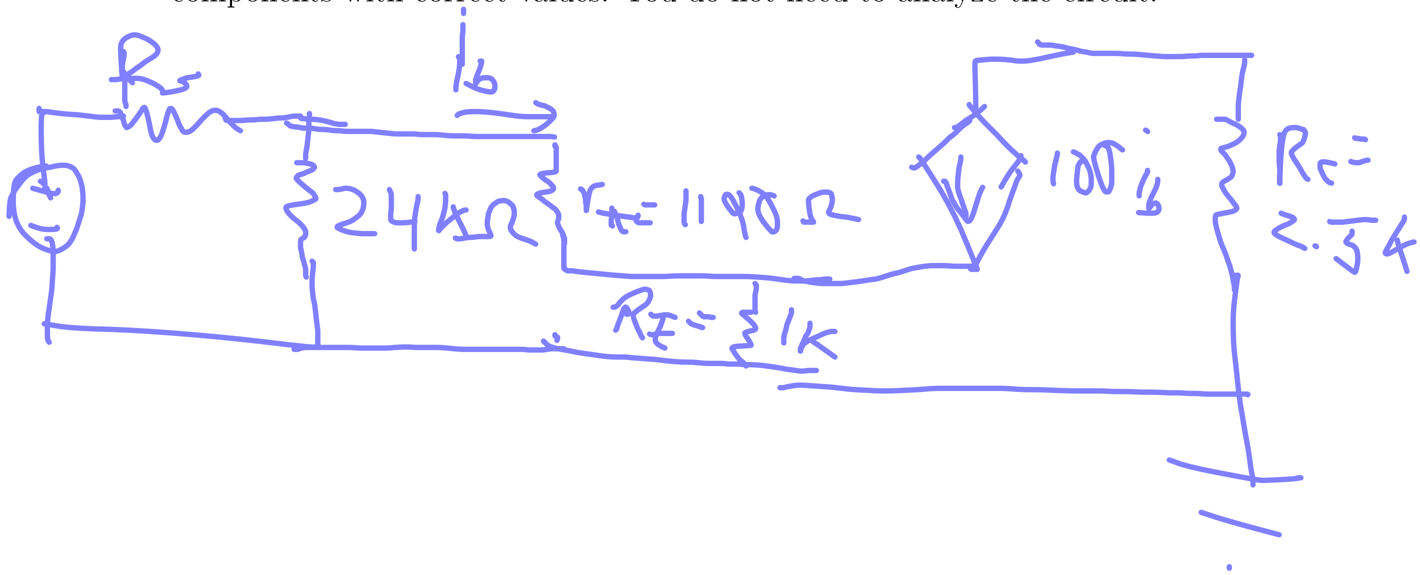
2.3 AC Circuit

Draw the AC circuit for the amplifier in the space below, and label all the components with correct values. You do not need to analyze the circuit.



3 BJT Logic (30%)

Consider the BJT Logic Inverter in the figure.

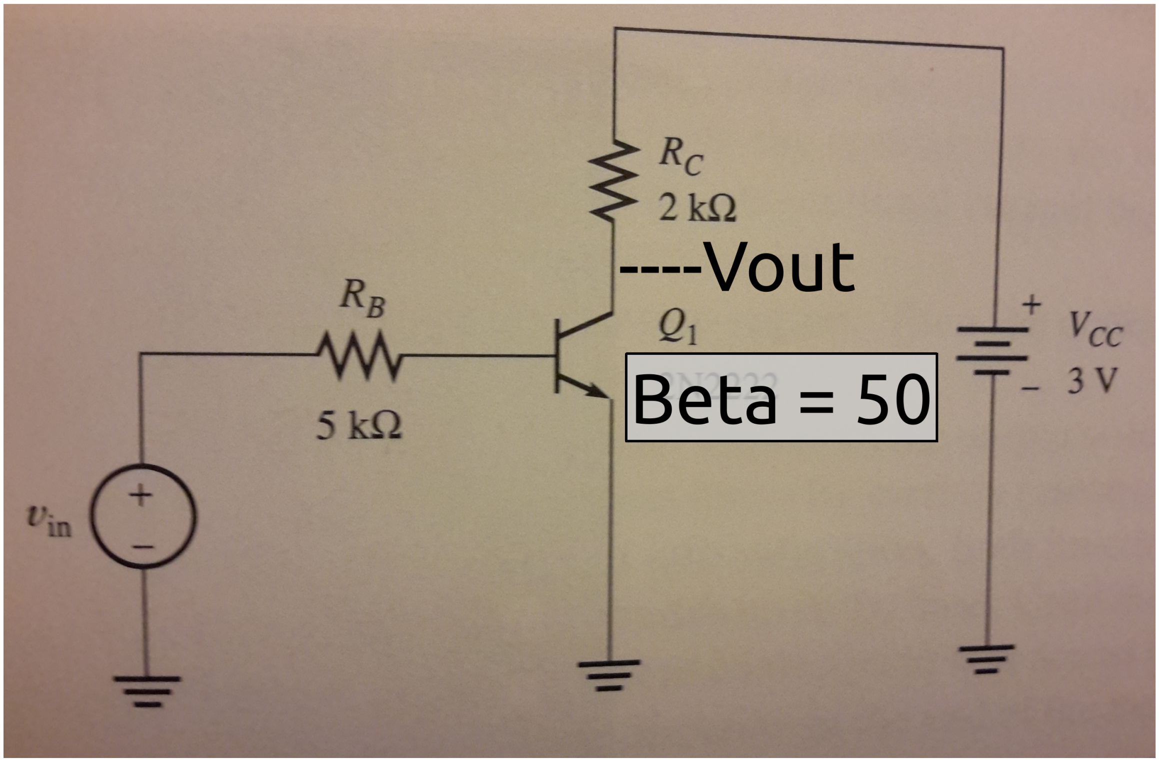


Figure from Hambley, *Electronics, 2nd Ed.*

3.1 Graphical Solution

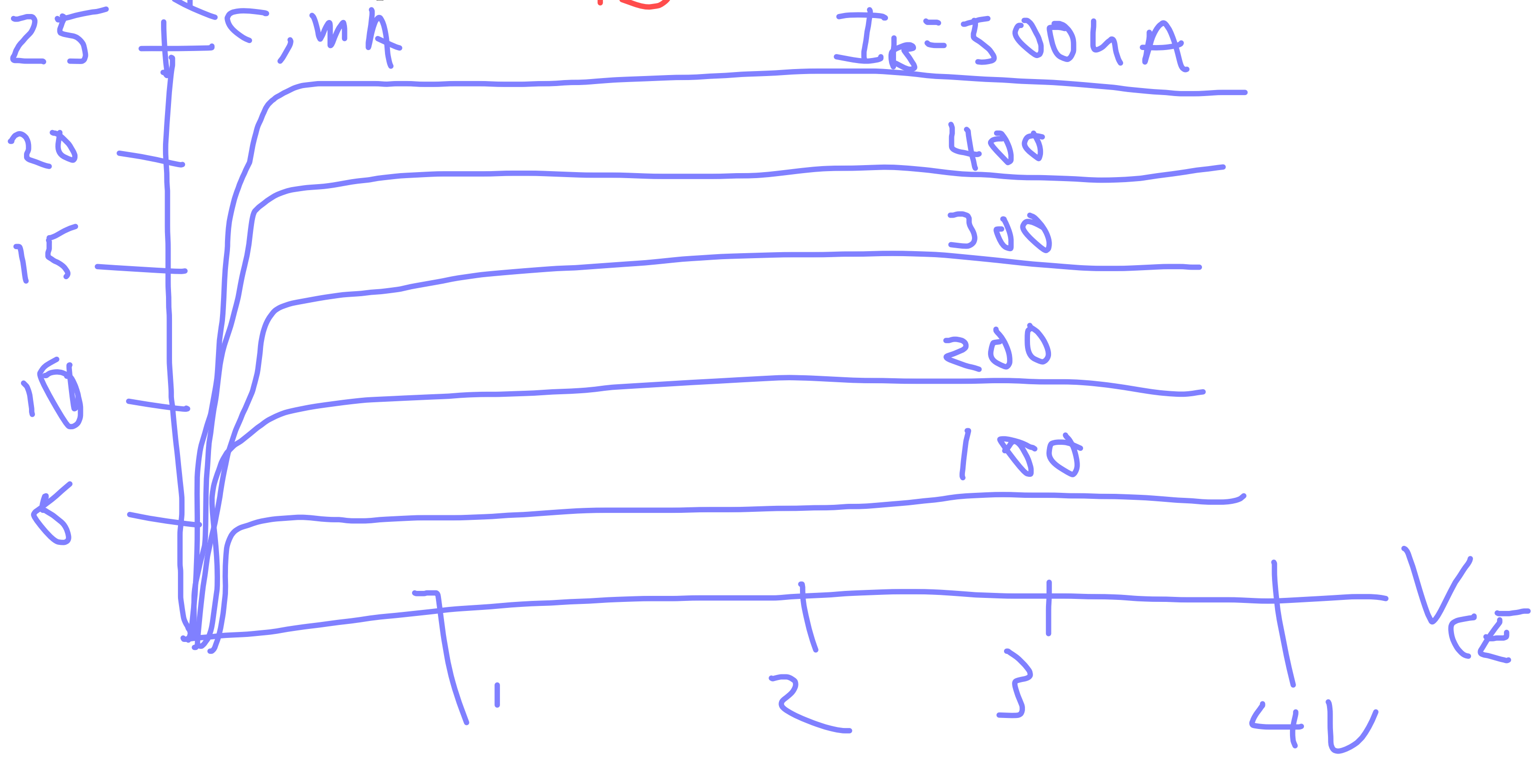
Draw the characteristic curves of the transistor for V_{CE} from zero to 4 Volts, and I_C from zero to the maximum possible for the circuit. Use a range of base currents sufficient to allow the input voltage, V_{in} to vary from zero to 3 Volts.

2.3V / 5kΩ = 460uA

3.2 Transfer Characteristic

Treating this circuit as an amplifier, with the transistor in active mode, write an equation for the output, V_C, as a function of the input, v_{IN}.

Graphical Solution 15



15

Transfer Characteristic

$$V_o = 3V - \frac{(V_{in} - 0.7V)}{5k\Omega} \times 50 \times 2k\Omega$$

$$= 17V - 20V_{in}$$