Electronics
EECE2412 — Fall 2016
Exam #2

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Name: Solutions :

General Rules:

- 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. Sharing of calculators is not allowed.
- 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 line 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 Short–Answer Questions (25%)

3 each

The arrow on a BJT is on the...
☐ Emitter ☐ Base ☐ Collector.

In a good amplifier, the BJT is in ...
☐ Saturation ☐ Cutoff ☐ Active mode.

The beta of a BJT is well–defined in the manufacturing process;
☐ True ☐ False.

The collector–emitter voltage, V_{CE} in saturation is ...
☐ 0.7 V ☐ 0.5 V ☐ 0.2 V.

The emitter current is ...
☐ A little less than ☐ Equal to ☐ A little greater than
... the collector current.

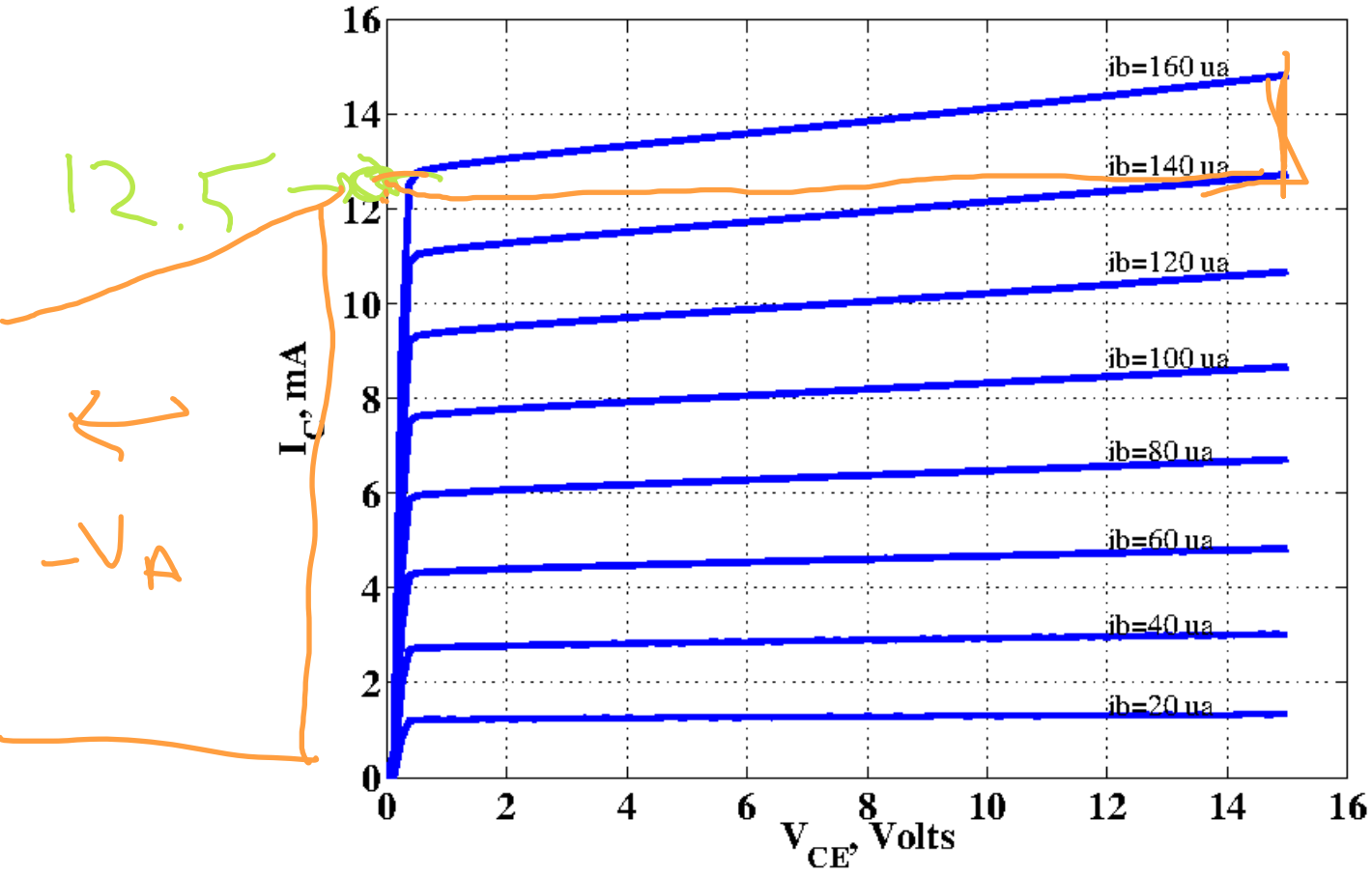
To draw the AC model of a circuit, a DC current source should be ...
☐ opened ☐ shorted ☐ used as is.

For a common–collector amplifier, ...
☐ $A_V \approx 1$ ☐ $A_I \approx 1$ ☐ $A_V \gg 1$.

In BJT logic, the collector current is highest when the output is, ...
☐ high ☐ low ☐ changing state.

2 BJT Characteristics and Bias (25%)

We have measured the characteristic curves of a transistor with the following results.



2.1 Beta

What is the beta of the transistor?

$I_C = 12.5\text{mA}$ $I_B = 160\mu\text{A}$

$\beta = I_C / I_B$

78

$\beta =$ 78 .

6

2.2 Early Voltage

What is the Early voltage of the transistor?

see triangle

$\frac{7.5\text{ V} - 0\text{ V}}{15\text{ mA} - 12.5\text{ mA}}$ $\times$ 12.5 mA - 0 mA

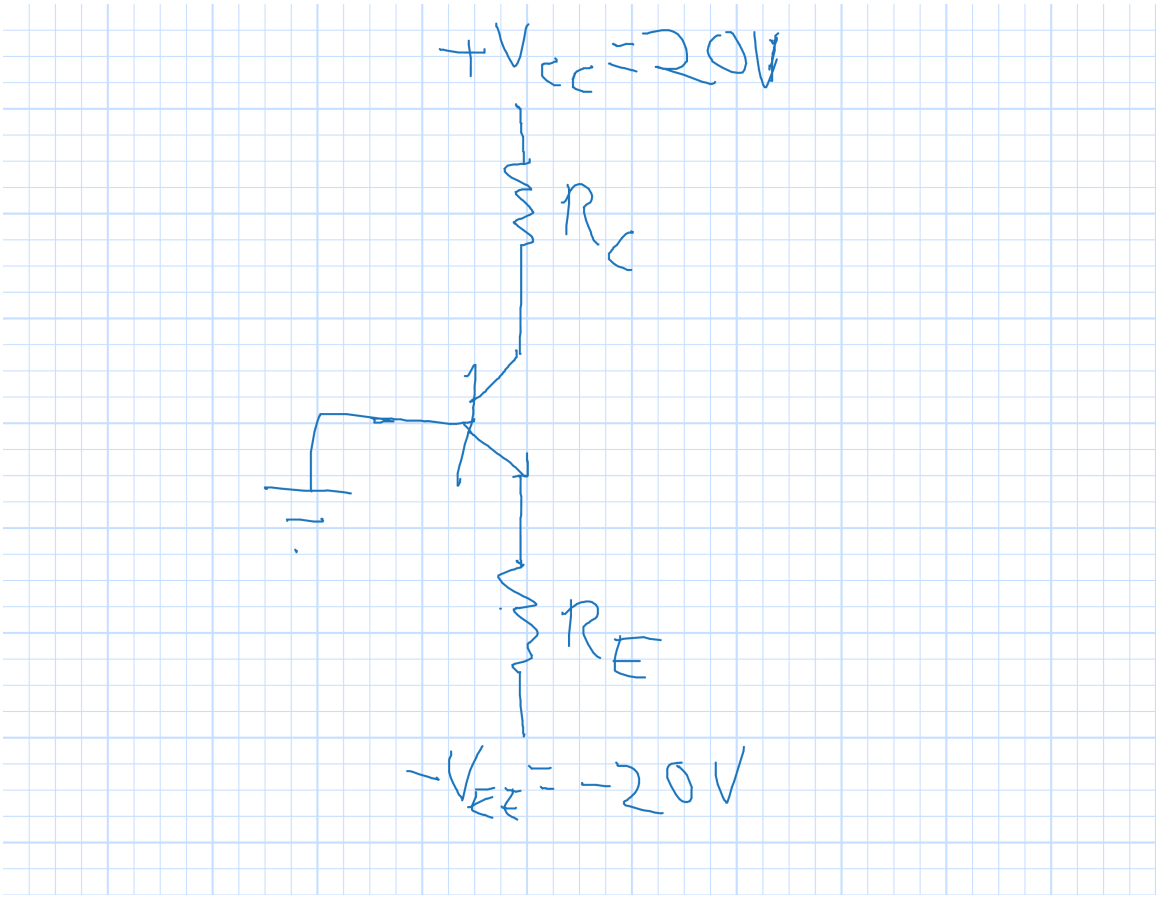
75

$V_A =$ 75 Volts.

12

2.3 Bias Circuit

Determine the Emitter resistor in the circuit below to obtain an operating point with current $I_C = 5$ mA and voltage $V_{CE} = 8$ V.



$V_{BE} = 0.7V$ $V_E = -0.7V$

$R_E = \dfrac{19.3V}{5mA \frac{79}{78}}$

$R_E = 3.8K$ Ohms.

Determine the collector resistor.

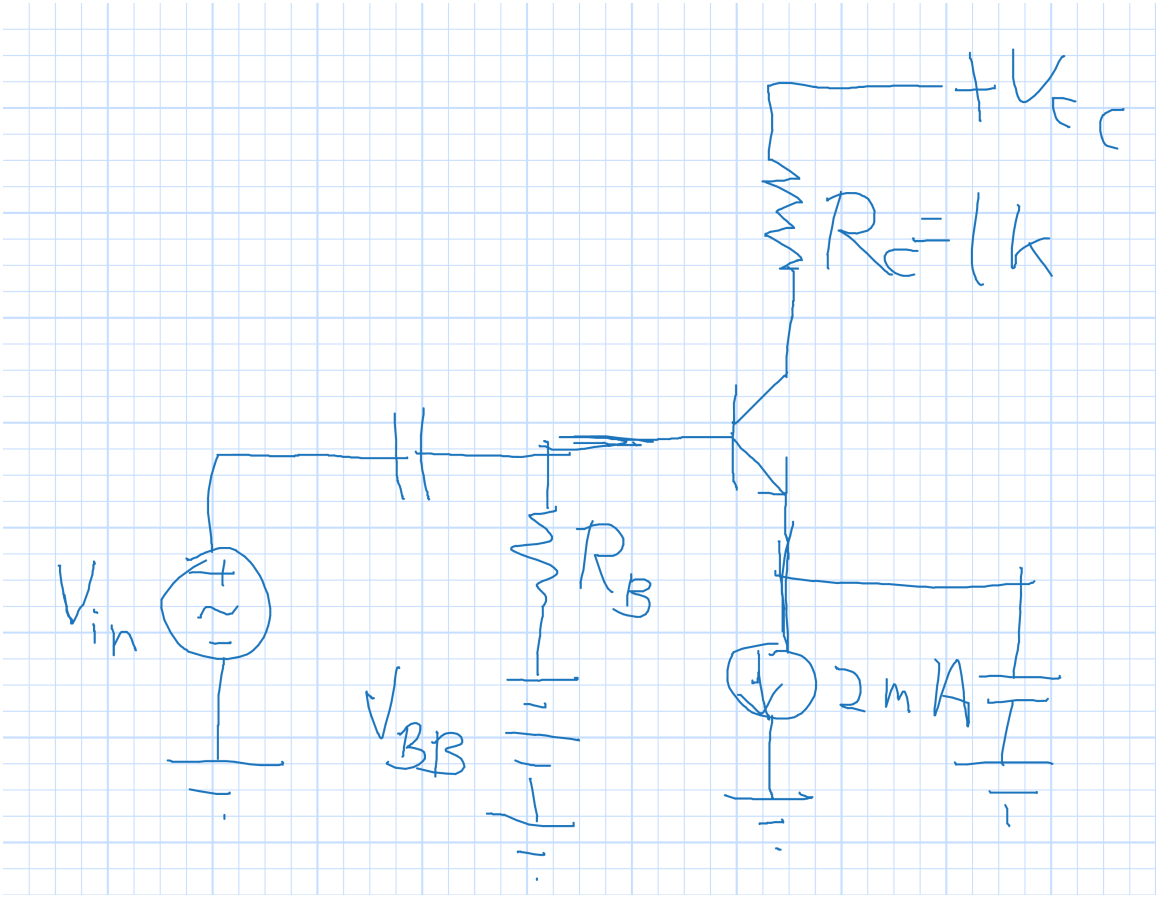
$V_C = V_E + 8V = 7.3V$

$R_C = \dfrac{20V - 7.3V}{5mA}$

$R_C = 2.5K$ Ohms.

3 BJT Amplifier Circuit (25%)

In the following circuit, $\beta = 160$, and $V_A = 100$ V.



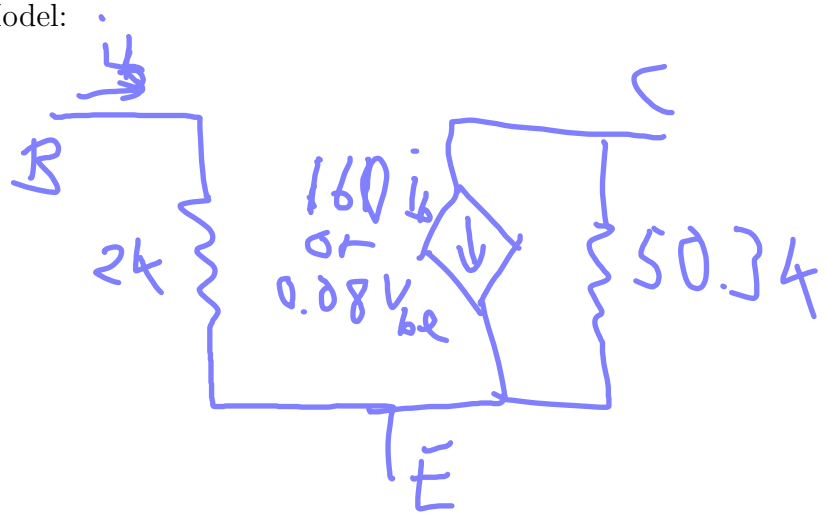
3.1 Small–Signal Model

Draw the small–signal pi model of the transistor with all component values labelled appropriately.

$r_\pi = \frac{\beta V_T}{I_C} = \frac{160 \times 25\,mV}{2mA\,\frac{160}{161}} \simeq 2k$ or $g_m = \frac{I_C}{V_T} = 0.08\,\frac{mA}{V}$

$r_o = \frac{V_A}{I_C} = \frac{100}{2mA\,\frac{160}{161}} \simeq 50.3k$

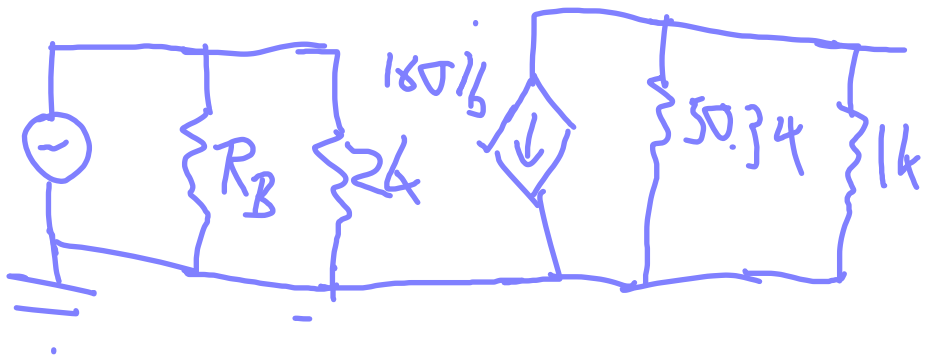
Pi Model:



3.2 AC Circuit

Draw the complete AC circuit including the transistor.

AC Circuit:



3.3 Gain

What is the voltage gain of the amplifier?

Neglect R_B and r_o

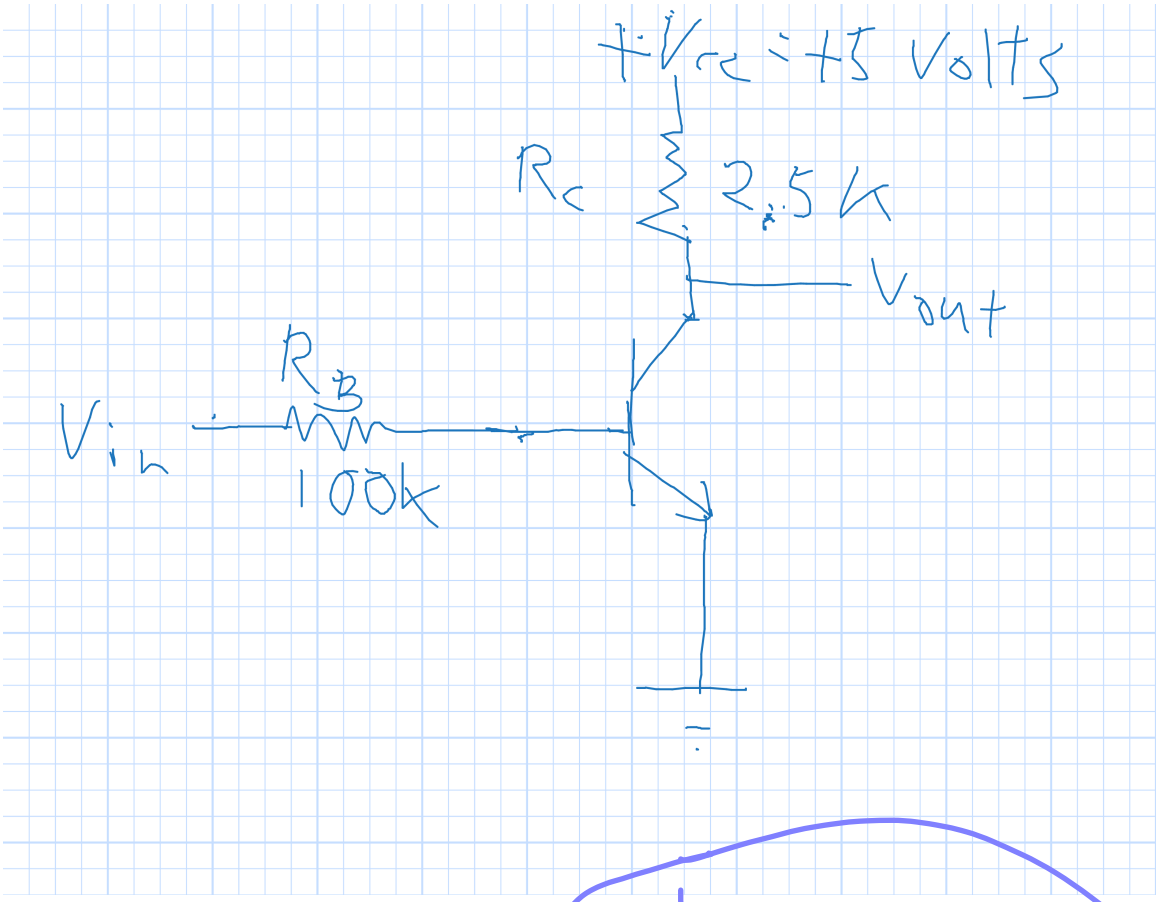
$V_o = -V_{in} \frac{R_c}{R_{Ti}} \beta = 80$

-80

$A_V =$ _____ .

4 BJT Logic (25%)

Consider the following logic inverter. For this transistor, $\beta = 100$, and the Early voltage can be neglected.



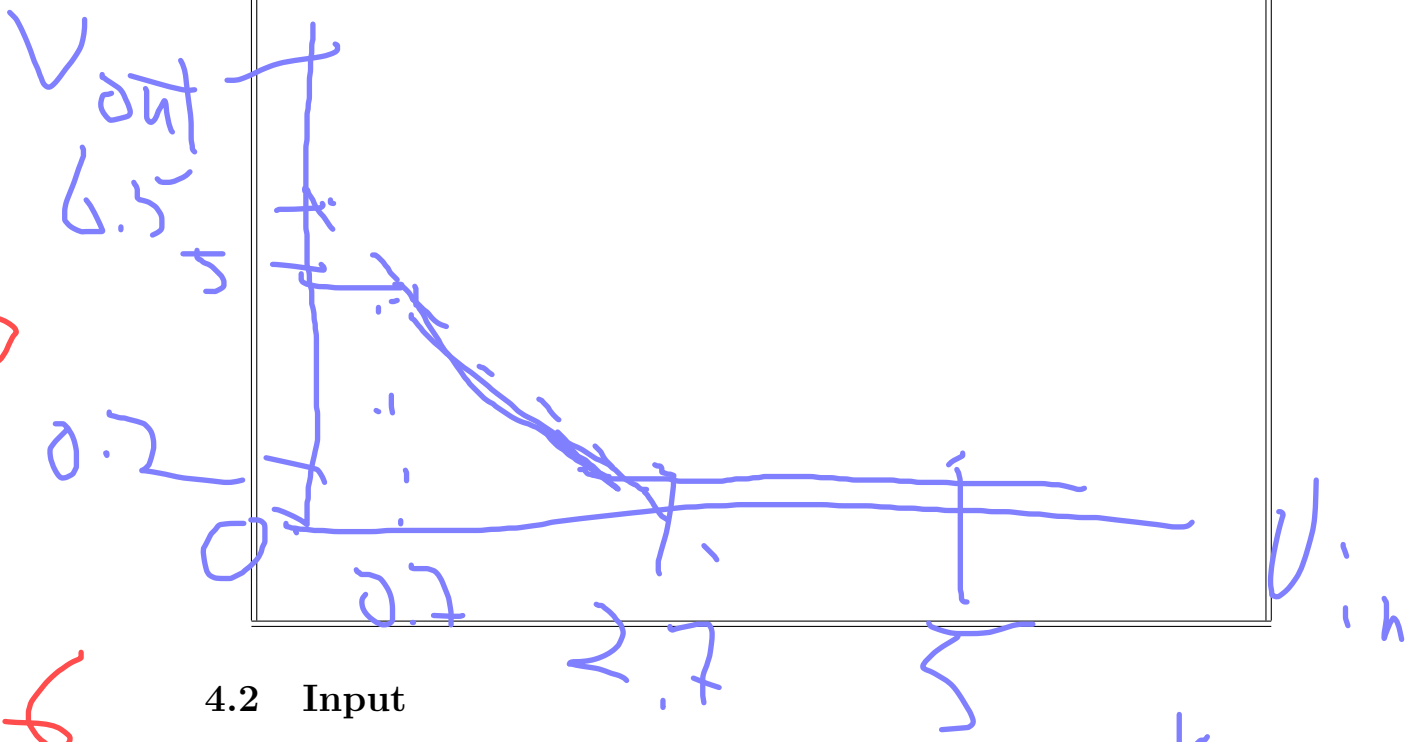
4.1 Transfer Function

Write an equation for the output voltage as a function of input voltage. Plot that equation using a dashed line for input voltage from zero to $V_{CC} =$ 5 Volts.

$V_{out} =$ _____ .

Plot the actual output voltage as a function of the input voltage over the range from zero to 5 volts as a solid line.

Transfer Function:



4.2 Input

What is the highest input voltage that can be considered low?

0.7 Volts

What is the lowest input voltage that can be considered high?

2.62 Volts

4.3 Output

What is the output voltage when the input is low?

5 Volts

What is the output voltage when the input is high?

0.2 Volts