Spring 2019 Purdue University

ECE 255: L11.2

BJT Circuit Analysis and Design

(Sedra and Smith, 7th Ed., Sec. 6.2)

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Announcements

Exam 1: Thursday, Feb. 7, 6:30 PM, LILY 1105.
(Weeks -1- 4 topics, semiconductors, diodes, **BJTs**. i.e. HW1-HW4)

Two practice exams are posted on BlackBoard

Professor Janes will conduct a help session for Exam 1 on Thursday, 2/7 at 1:30 PM in ME 1061.

Spice 1 project postponed until Monday, Feb. 11

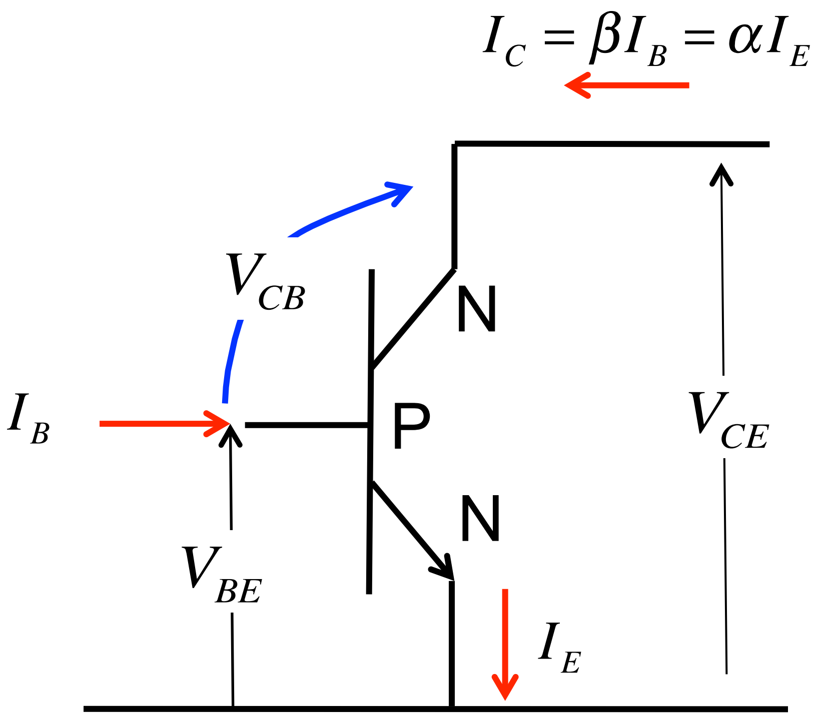
Note that there was an error in Lecture 11 Slide 8. Now corrected (and L11 has been split into two parts)

Announcements

We will have class on Friday, Feb. 8.

The topic will be MOSFETs. Sedra and Smith 5.1 and 5.2

NPN Common emitter (active region)



$$I_C = I_S e^{V_{BE}/V_T} \qquad I_B = \frac{I_S}{\beta} e^{V_{BE}/V_T}$$

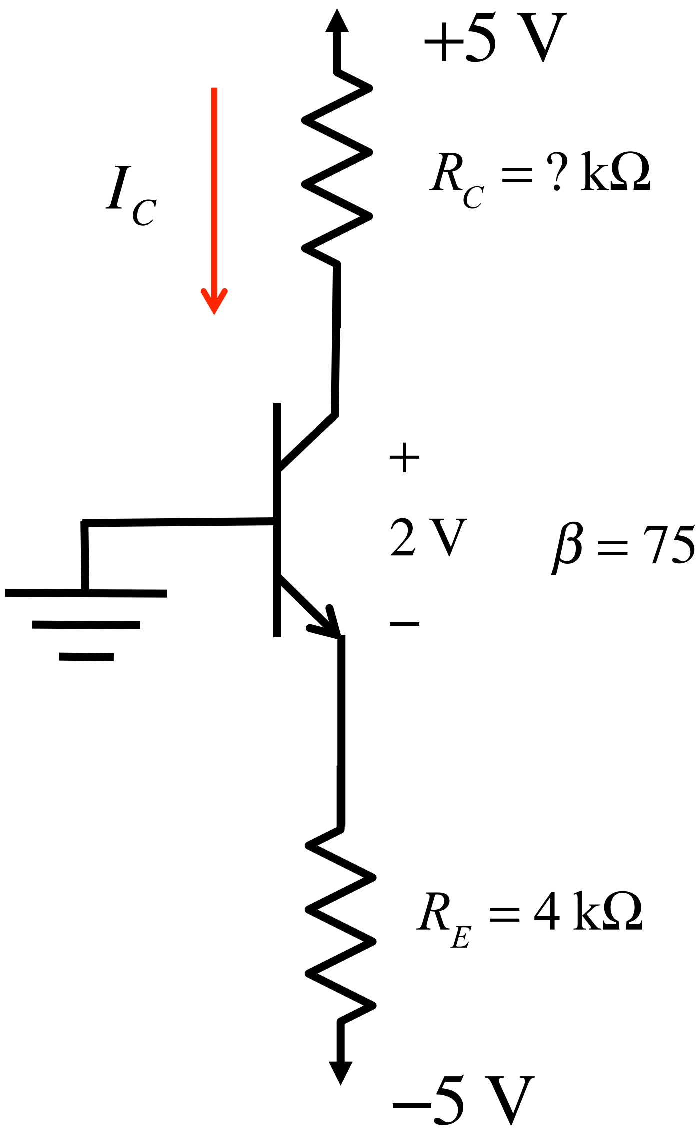
$$I_C = \beta I_B \qquad I_C = \alpha I_E$$

$$\beta = \frac{\alpha}{1-\alpha} >> 1 \qquad \alpha = \frac{\beta}{\beta + 1} < 1$$

BE: **FB** $V_{BE} > 0$

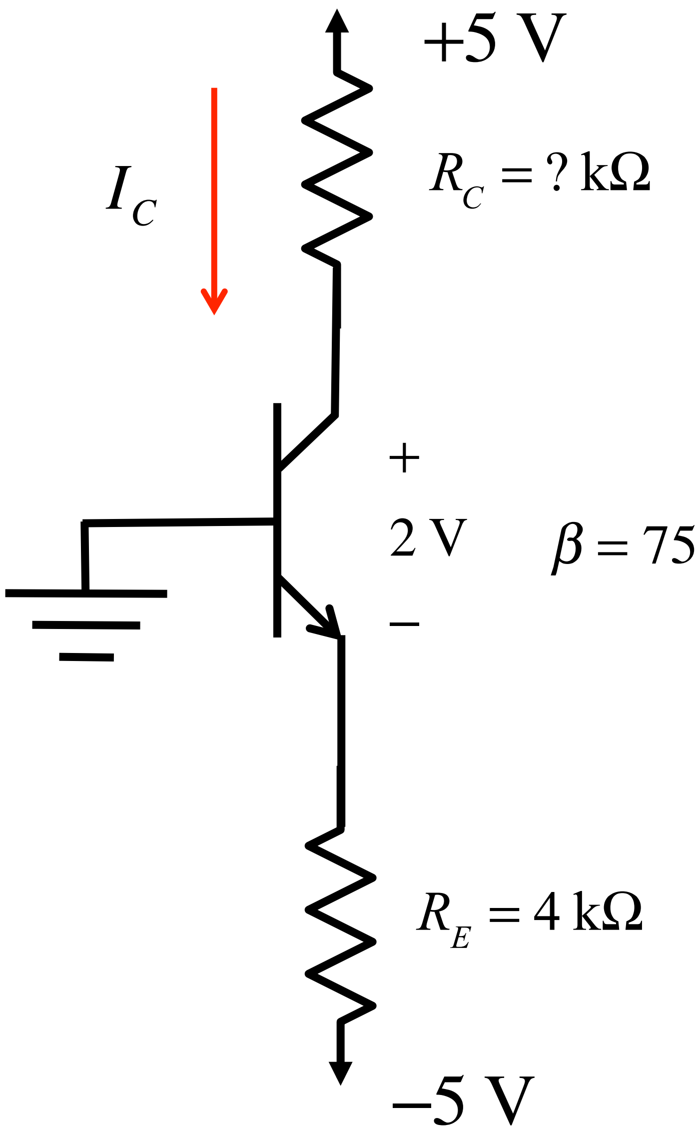
BC: **RB** $V_{CB} = V_{CE} - V_{BE} > 0$

NPN DC circuit analysis



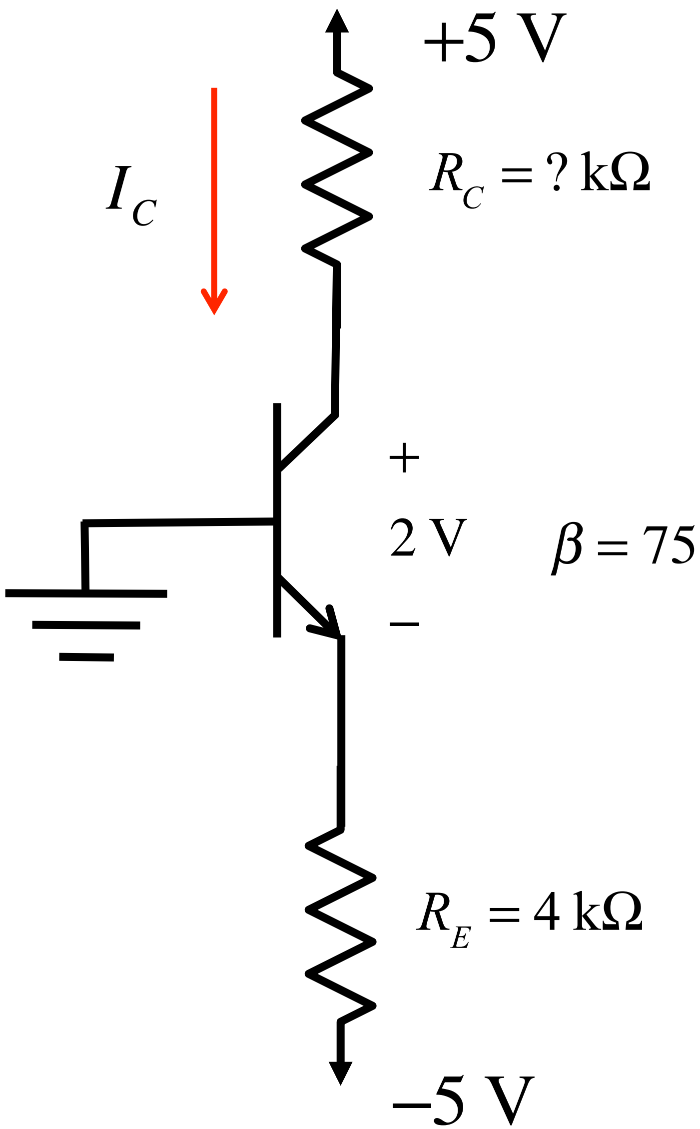
Find I_C and R_C

DC circuit analysis

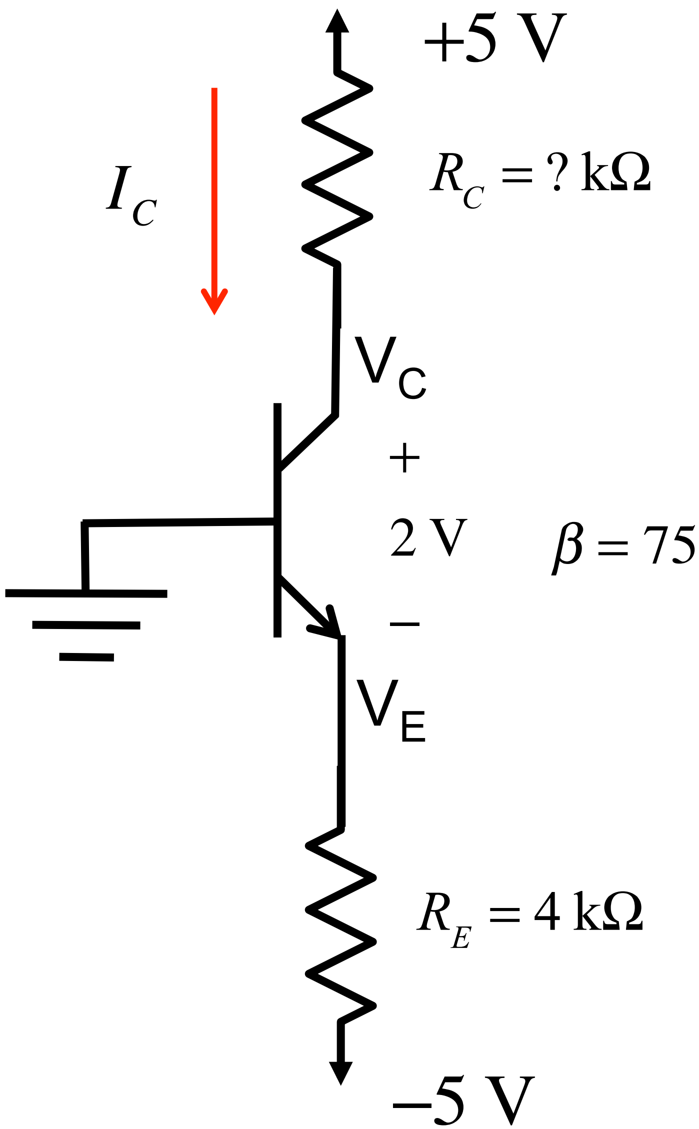


1) Assume active region
2) Find I_E
3) Find I_C
4) Find V_C
5) Find R_C
6) Check: Active region?

DC circuit analysis



DC circuit analysis



Circuit: V_B = 0V
Forward Active: V_{BE} = 0.7V
=> V_E = -0.7V

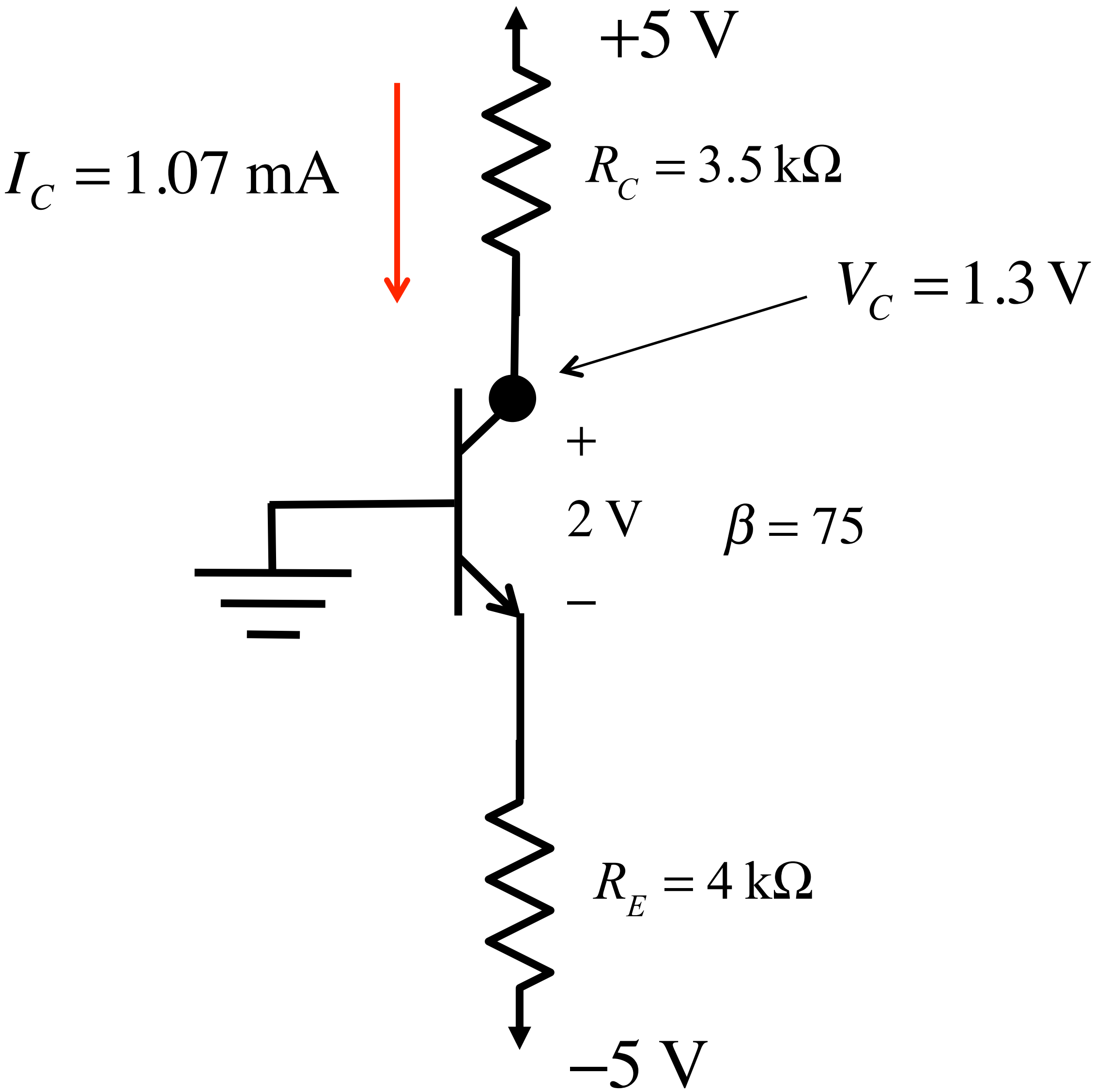
I_E = 4.3V/4kΩ = 1.08 mA

$I_C = \alpha\, I_E$ = 1.07 mA

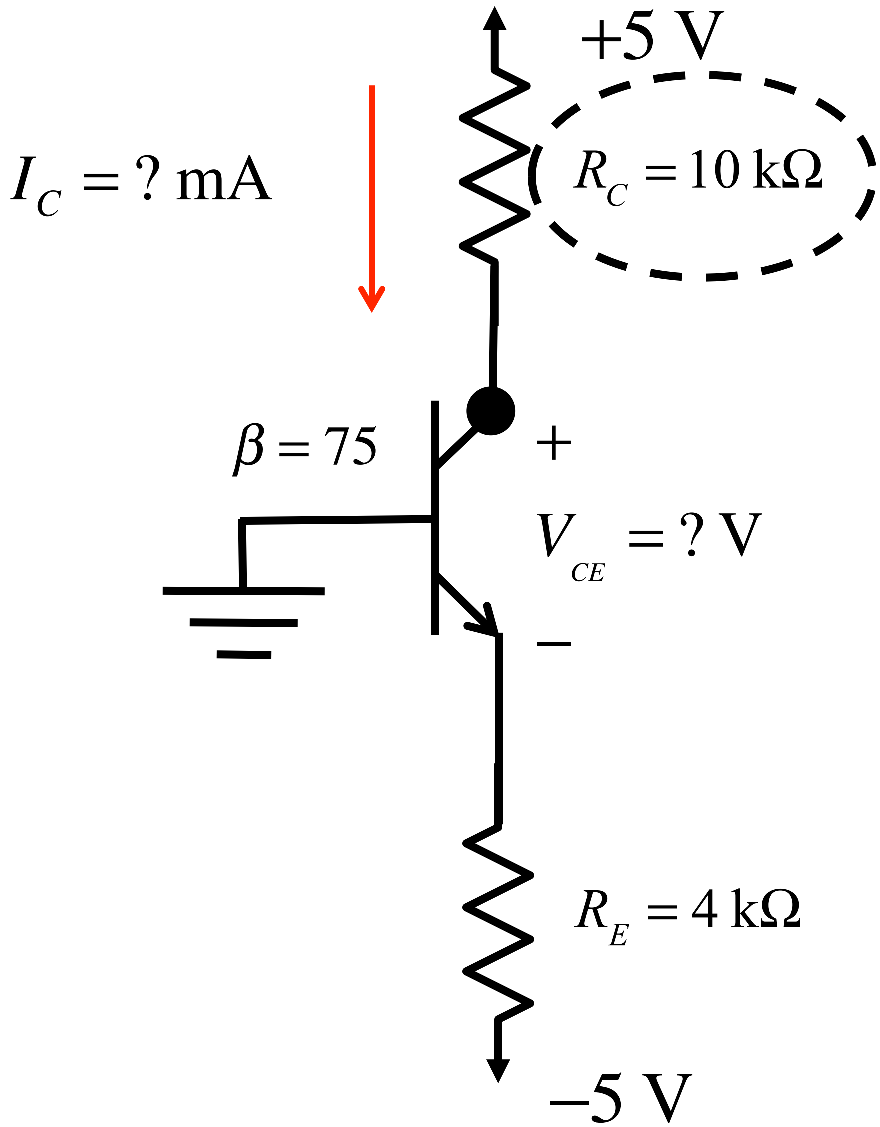
Specified: V_{CE} = 2V
V_E = -0.7V => V_C = 1.3 V

Voltage across R_C = 3.7V
R_C = 3.5 kΩ

DC circuit analysis: Result

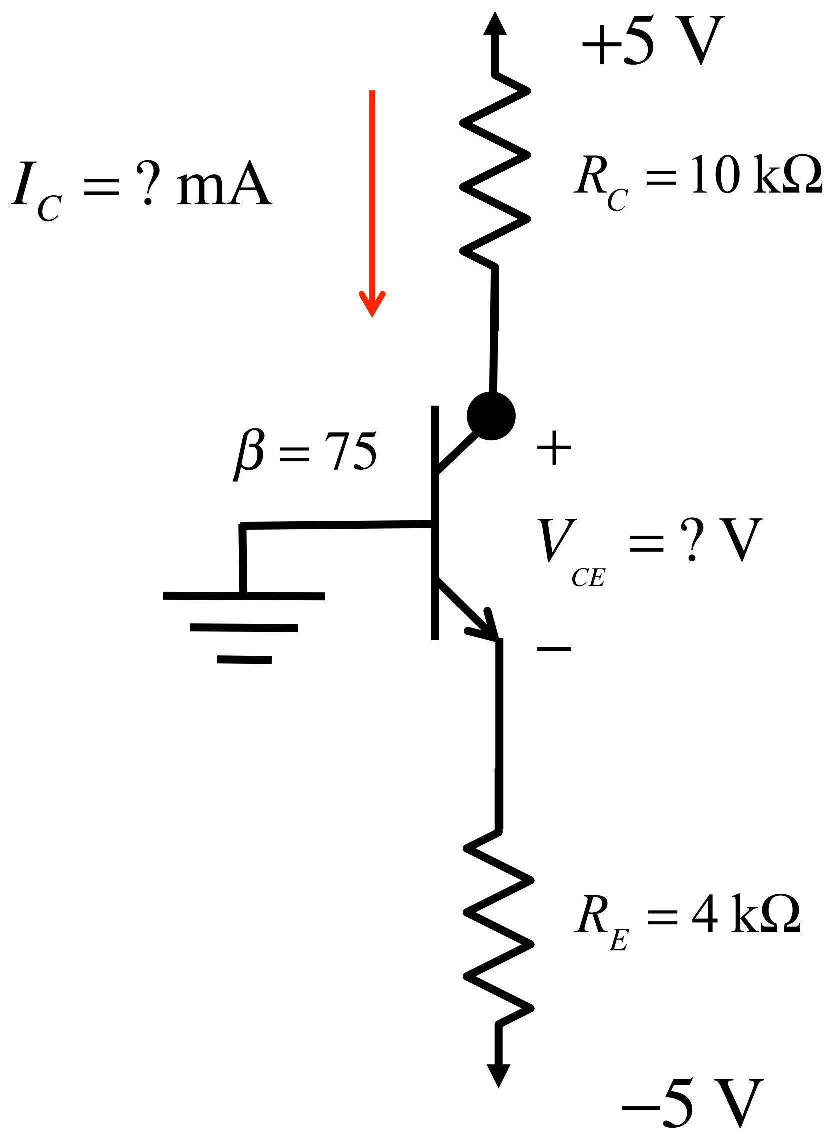


Now change the problem



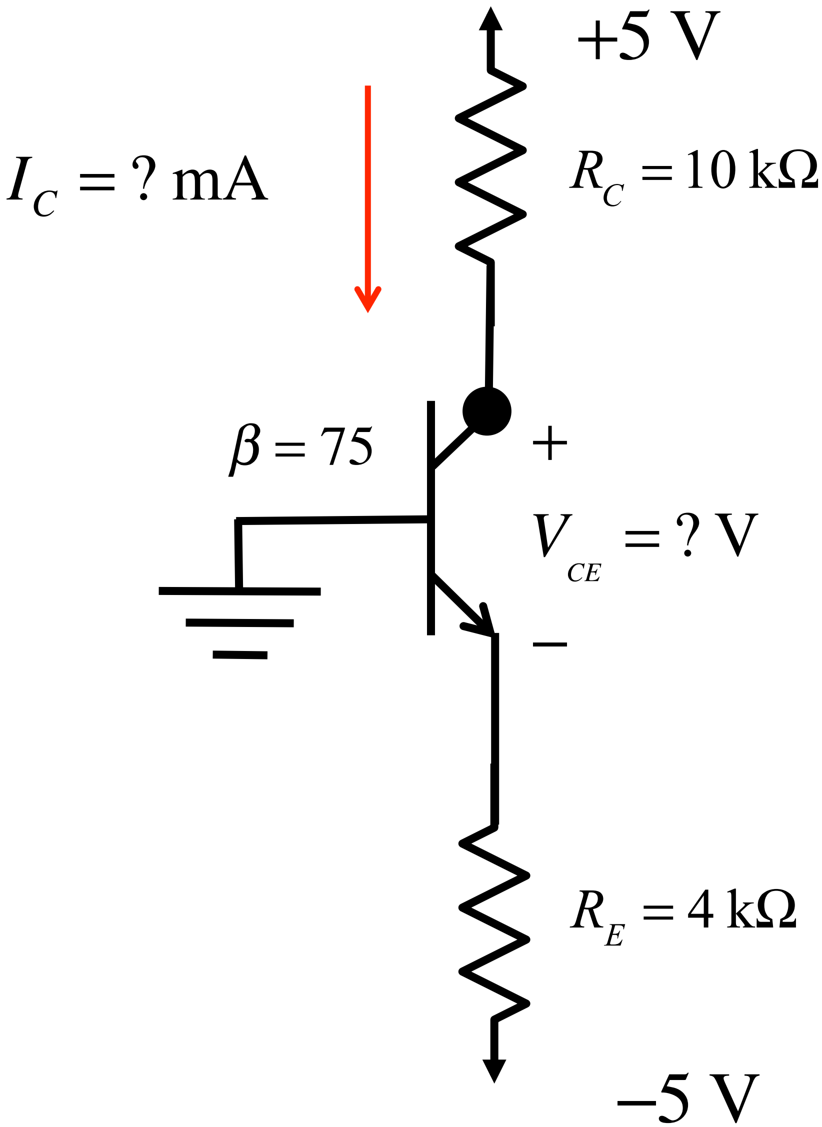
Find I_C and V_{CE}

Now change the problem

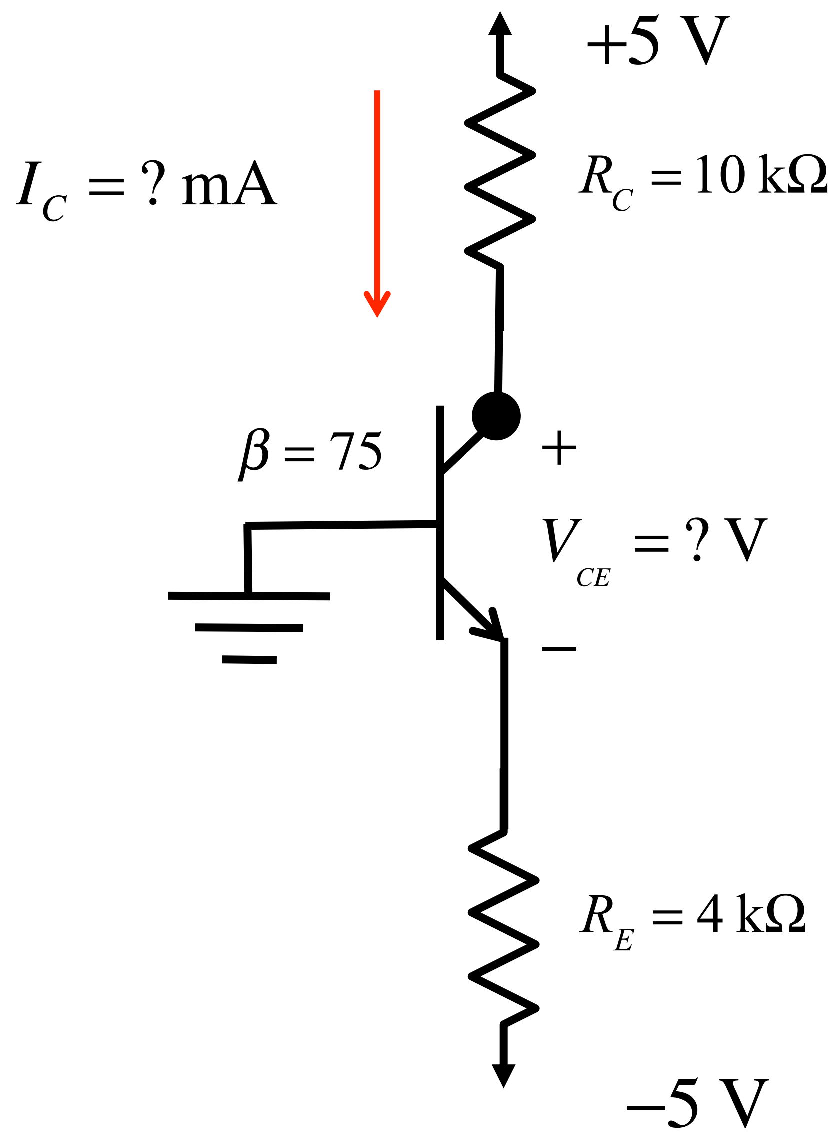


1) Assume active region
2) Find I_E
3) Find I_C
4) Find V_C
5) Find R_C
6) Check: Active region?

Now change the problem



Now change the problem

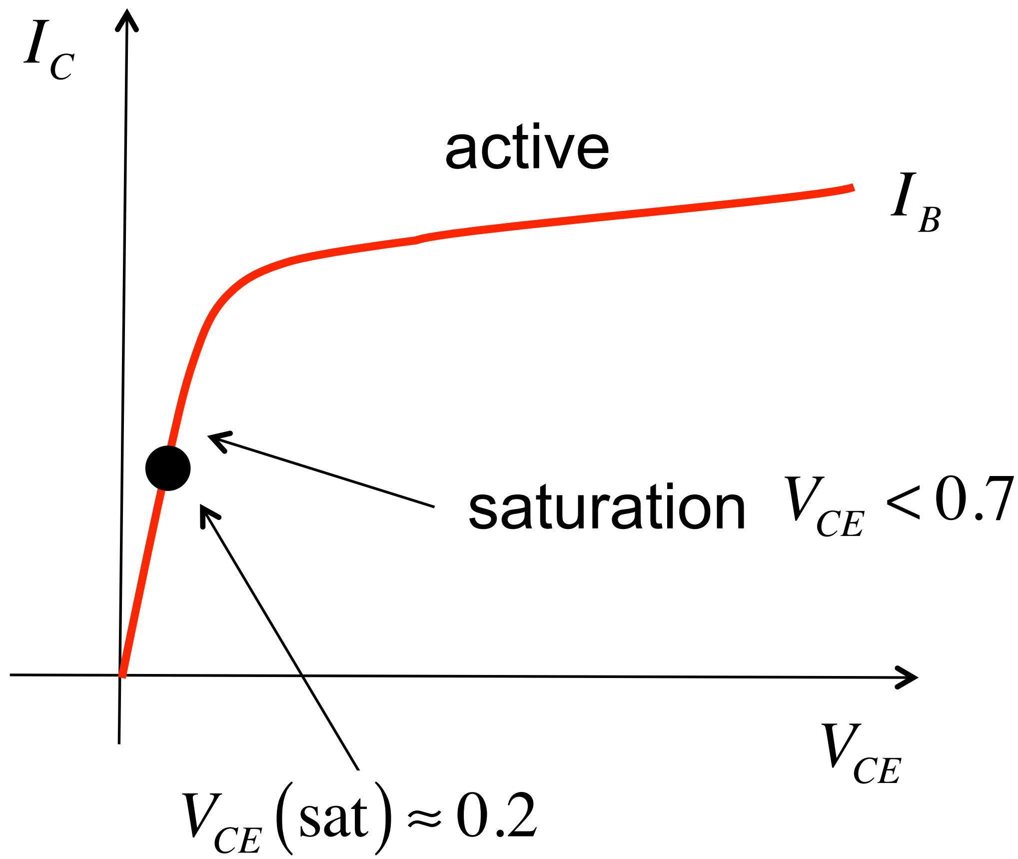


$$I_E = \frac{-0.7-(-5.0)}{4\ \text{k}\Omega} = 1.08\ \text{mA}$$

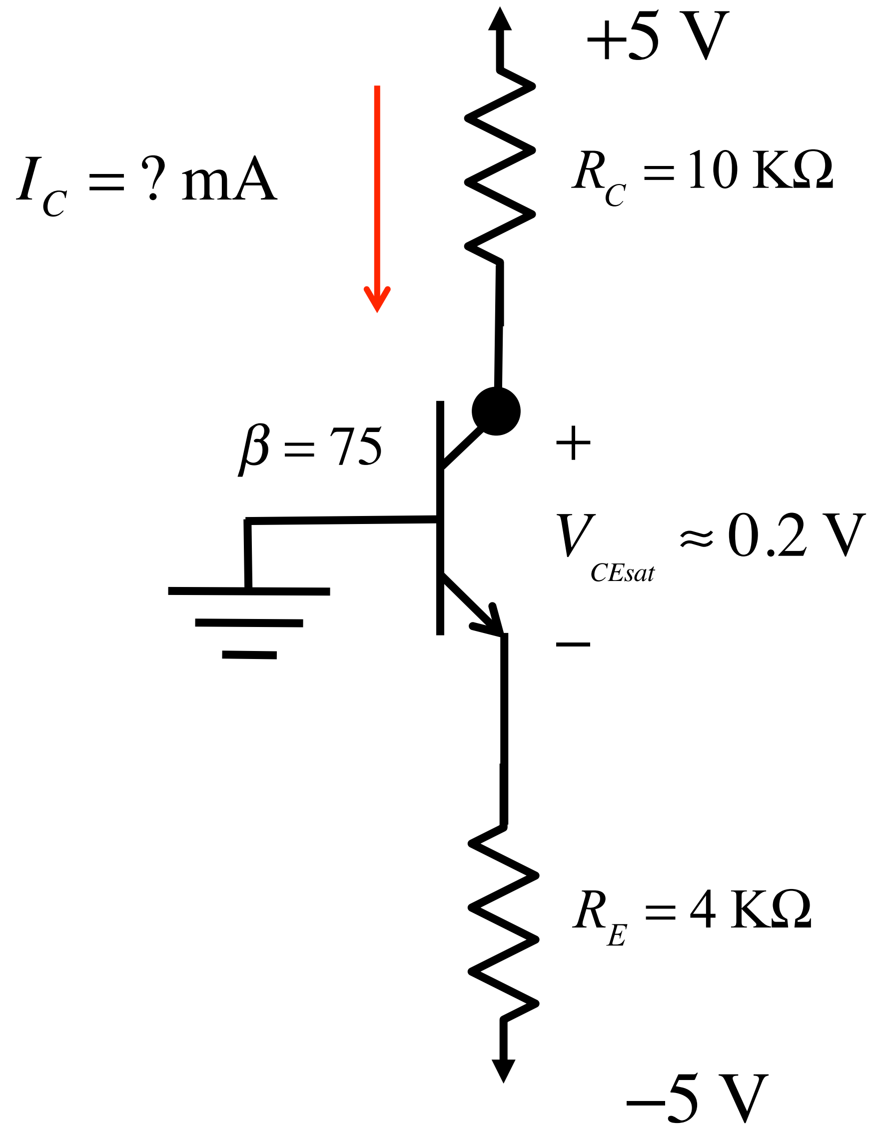
$$I_C = \frac{\beta}{\beta+1} I_E = 1.07\ \text{mA}$$

$$V_C = 5 - 1.07 \times 10 < 0\ !$$

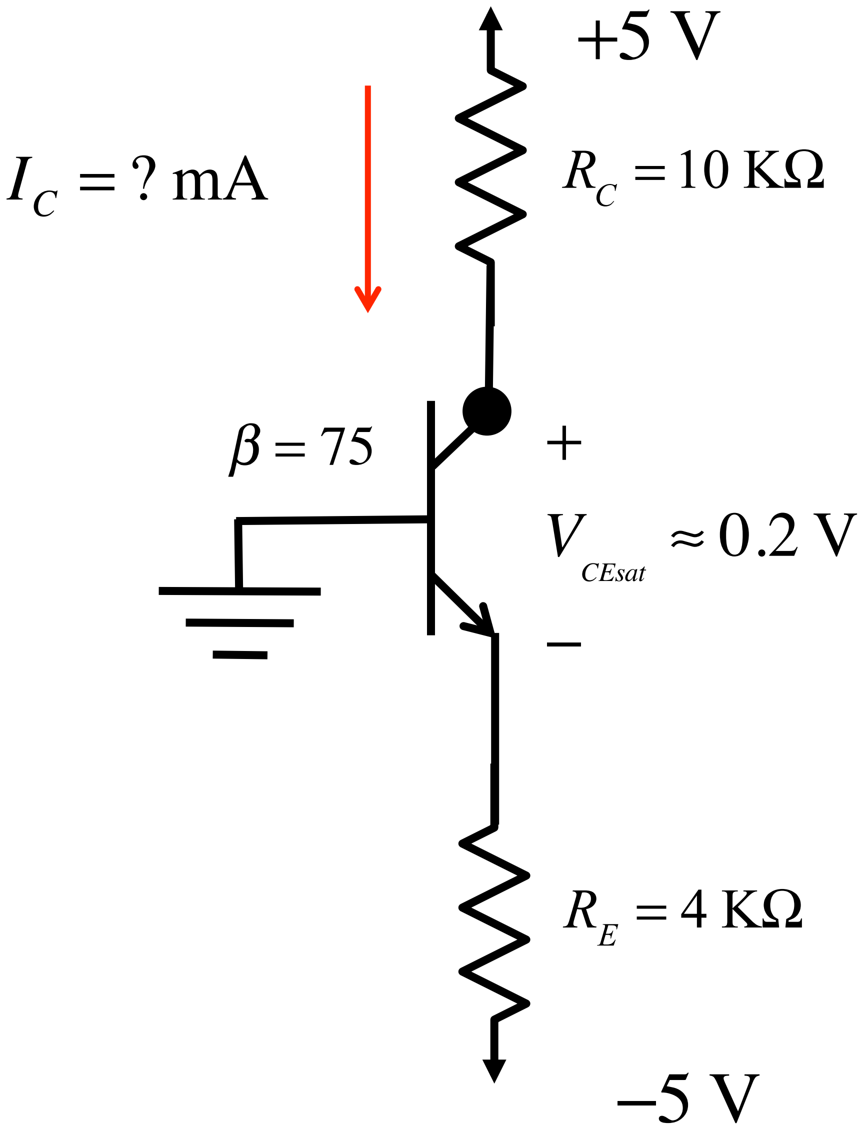
The transistor is saturated!



Saturation analysis



Saturation analysis: result

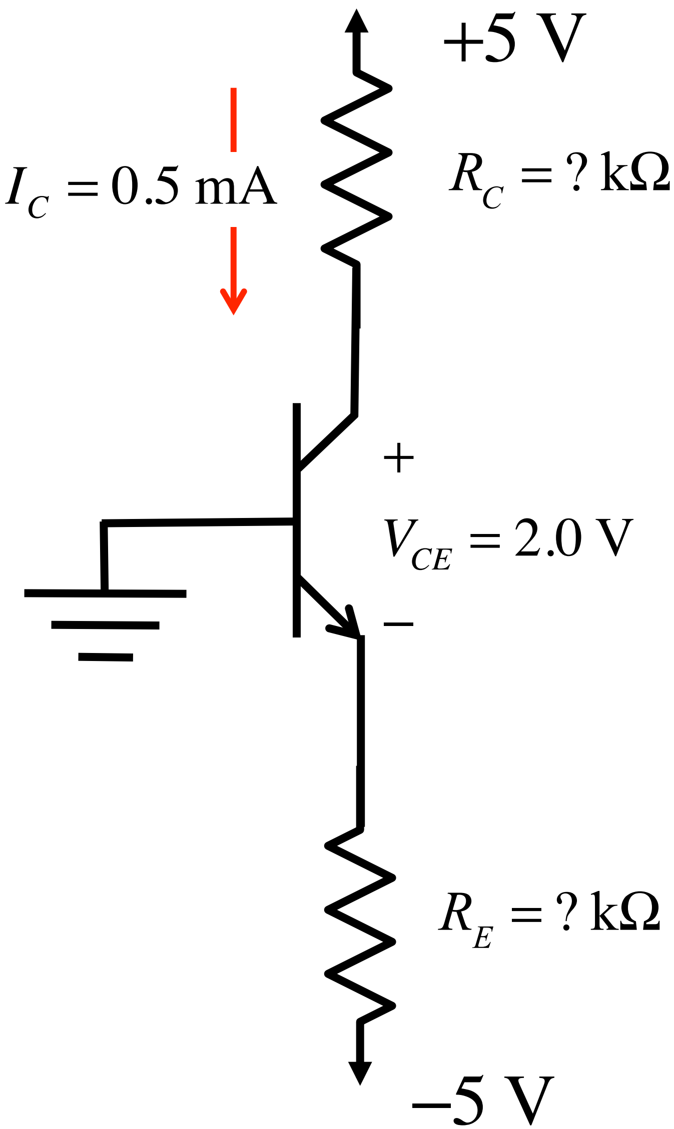


$$I_E = \frac{-0.7-(-5.0)}{4\ \text{k}\Omega} = 1.08\ \text{mA}$$

$$V_C = -0.7+0.2 = -0.5 < 0$$

$$I_C = \frac{5-(-0.5)}{10\ \text{k}\Omega} = 0.55\ \text{mA}$$

DC circuit **design**

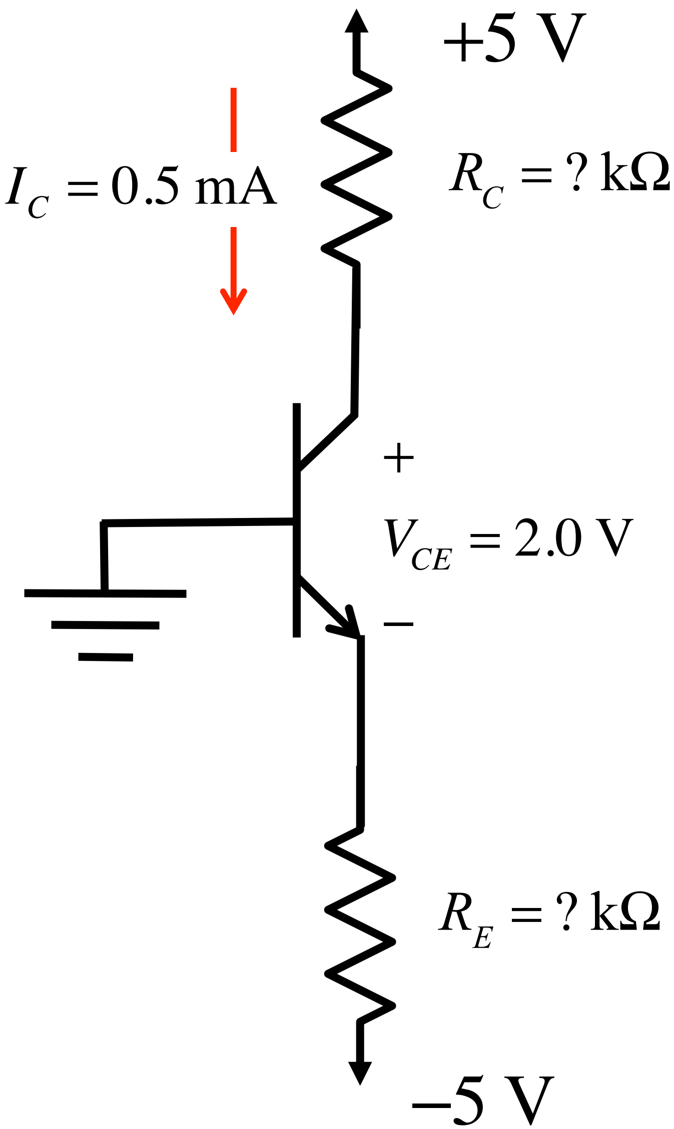


Specify R_C and R_E so that:

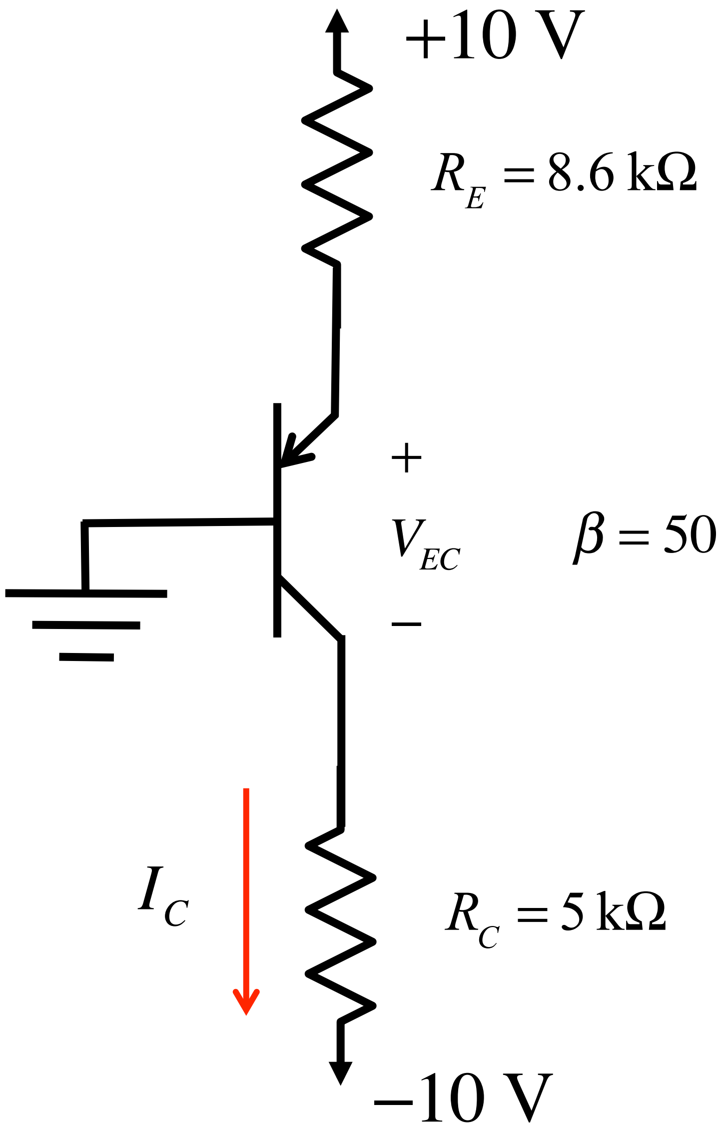
$I_C \approx 0.5$ mA	$V_{CE} \approx 2.0$ V

$\beta = 75$

NPN DC circuit **design**

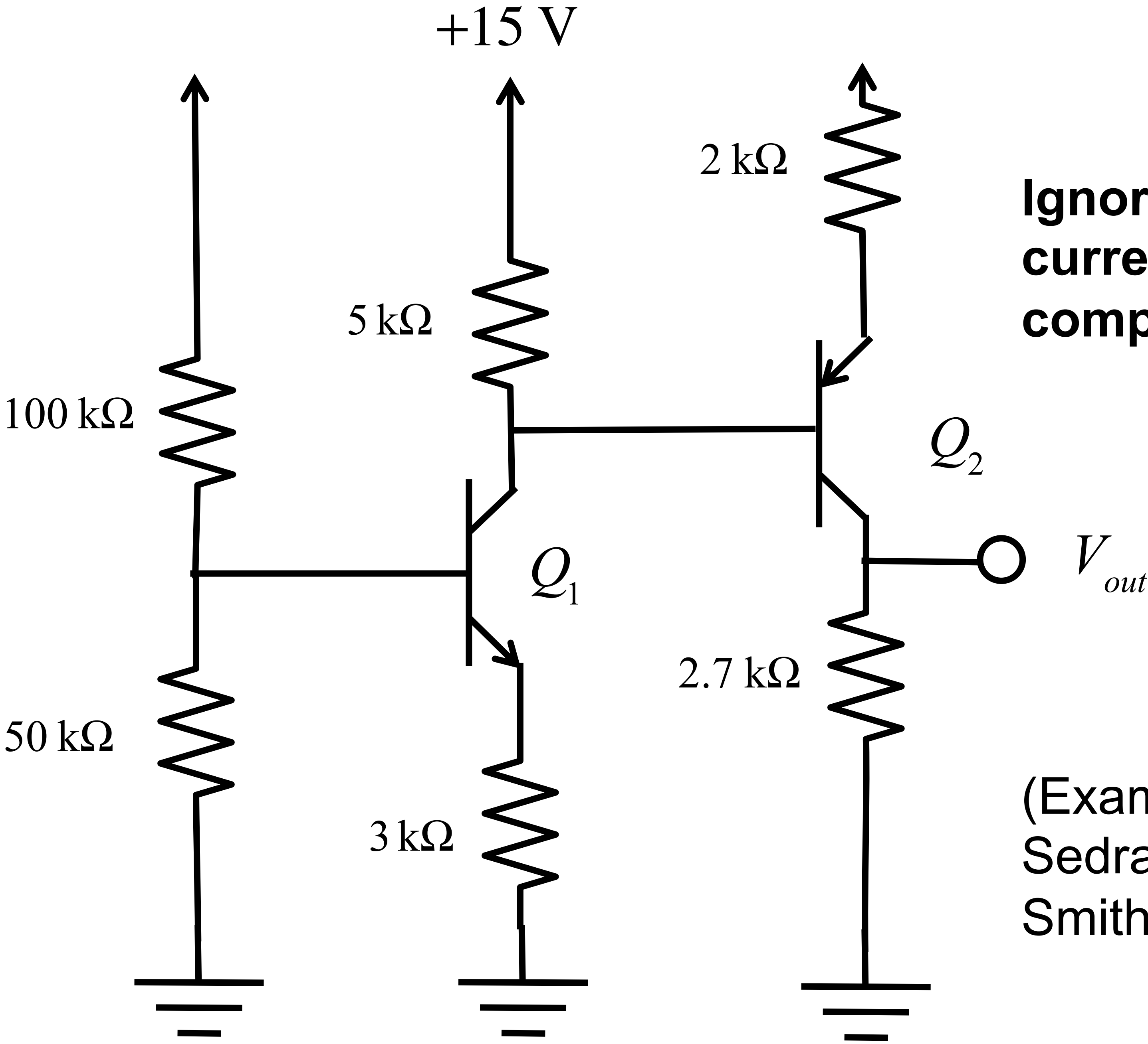


PNP Circuit Analysis



Find I_C and V_{EC}

NPN and PNP Circuit Analysis



Ignore base currents and compute V_{out}

(Example 6.11 Sedra and Smith)

Summary

In analysis, assume an operating region, do the analysis, then check that the proper operating region was assumed.

Generally, design is "easier" than analysis (but more open).

BJT Circuit Analysis and Design

1) NPN BJT Circuit Analysis and Design
2) PNP Circuits
3) NPN and PNP Circuits