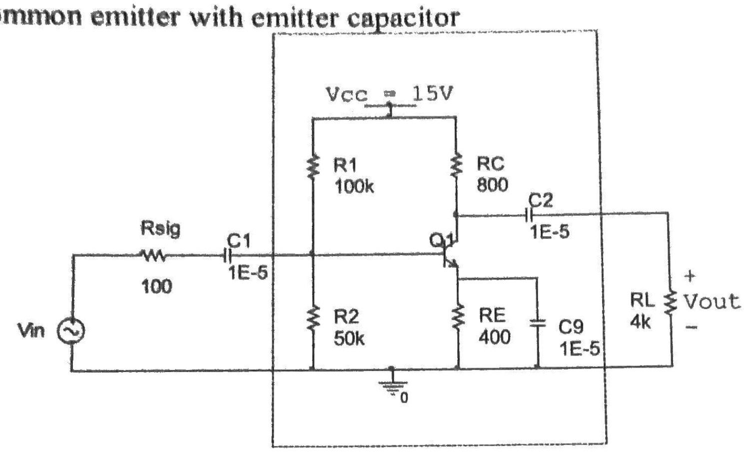
ECSE-2050

**Introduction to Electronics**
**Summer 2020** **Name** ____________

# Homework 16

In all problems, you may assume that $V_{CEsat} \sim 0.2V$, $V_{BE} \sim 0.7V$ and $r_o \rightarrow \infty$ when the transistor is in the forward active region. Also, the thermal voltage is Vth = 26mV.

## Problem 1) Common emitter with emitter capacitor




a) For β = 100, verify that the DC bias characteristics are consistent with a transistor in the forward active region of operation.
b) Determine the small signal parameters $r_\pi$, $g_m$ and $r_e$.
c) Sketch the hybrid-π small signal model for the circuit.
d) Sketch the Tee small signal model for the circuit.
e) Using the Tee model, determine the input impedance, Rin, looking into the 'left' side of the dashed box.
f) Using the Tee model, determine the output impedance, Rout, looking into the 'right' side of the dashed box.
g) Using the Tee model, determine the open circuit voltage, Avo, gain using the dashed box to define the voltage amplifier model.
h) Determine the overall gain, Av = Vout/Vin.
i) In this circuit, why would replacing Rsig with a 1kΩ resistor be problematic?

A: $V_{Th} = 5V$ $R_{Th} = R_1 \| R_2 = 33{,}333$ $I_B = \frac{5-0.7}{33333+(101)400} = 5.83\times10^{-5}$ A

B: $r_\pi = \frac{26mV}{5.83\times10^{-5}} = 445.82$

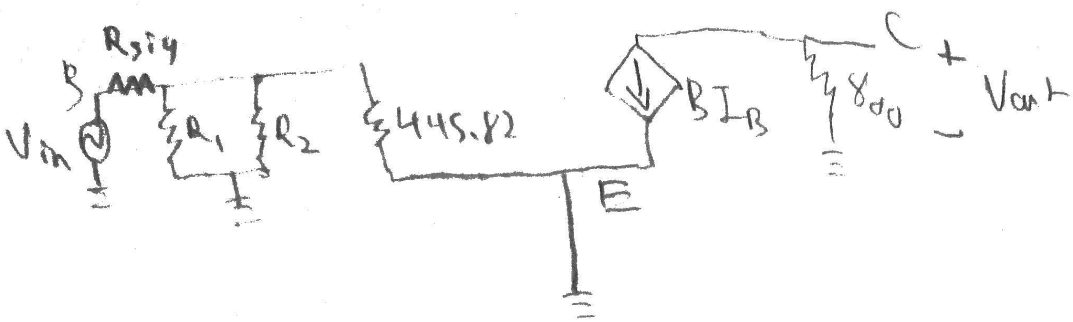
$g_m = .224$

$r_e = 4.414$

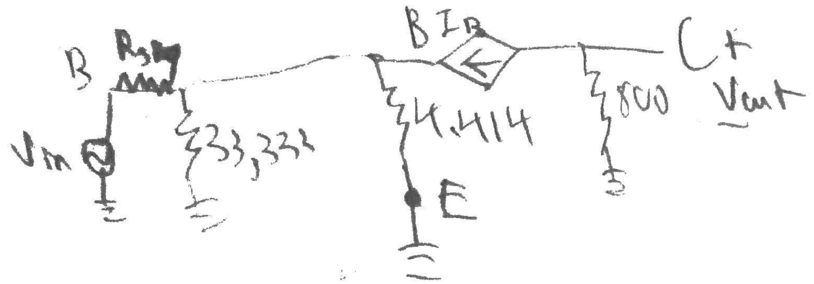
J. Braunstein
Rensselaer Polytechnic Institute

Revised: 8/1/2020
Troy, New York, USA

C:




D:




E: $R_{in} = R_{TH} || R_{\pi} = 200.8$

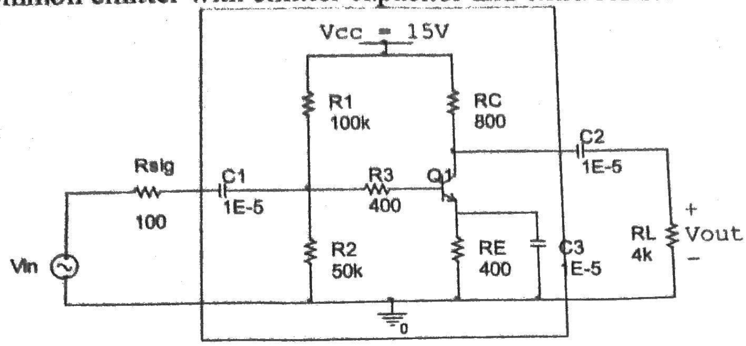
F: $R_{out} = R_C = 800$

G: common emitter with Ce: $A_{vo} = -g_m R_C = -179.45$

H: $A_v = \frac{R_{in}}{R_{in}+R_{sig}} \cdot A_{vo} \cdot \frac{R_L}{R_L+R_{out}} = -149.5$

I: It decreases our overall circuit gain and changes the predictability of Rin. Furthermore it almost isn't small signal anymore.

**Problem 2)** Common emitter with emitter capacitor and extra resistor




a) For $\beta = 100$, verify that the DC bias characteristics are consistent with a transistor in the forward active region of operation. The DC bias characteristics should be very close to the result found in part a of problem 1.
b) Determine the small signal parameters $r_\pi$, $g_m$ and $r_e$.
c) Sketch the hybrid-$\pi$ small signal model for the circuit.
d) Sketch the Tee small signal model for the circuit.
e) Using any model, determine Rin, Rout and Avo.
f) Determine the overall gain of the circuit.

A: $V_{Th} = 5V$ $\quad R_{TH} = R_1 \| R_2 + R_3 = 33733$

$$I_B = \frac{V_{th} - V_{BE}}{R_{TH} + (101)R_E} = 1.27\times10^{-4} A \rightarrow V_{CE} > 0.2V$$

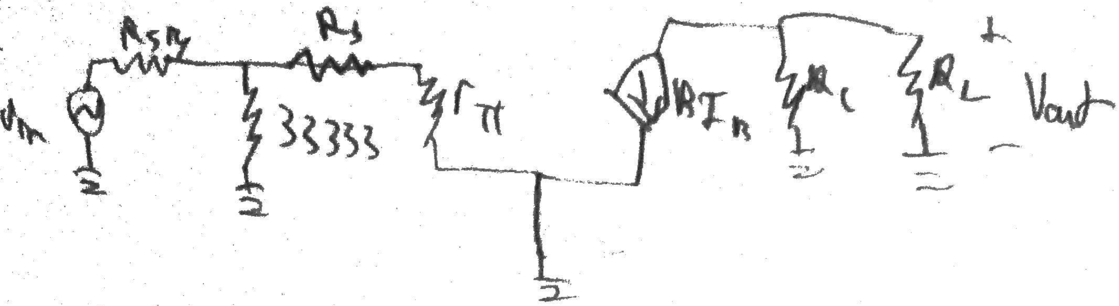
forward active

B: $r_\pi = \frac{V_{tH}}{I_B} = 204.72$

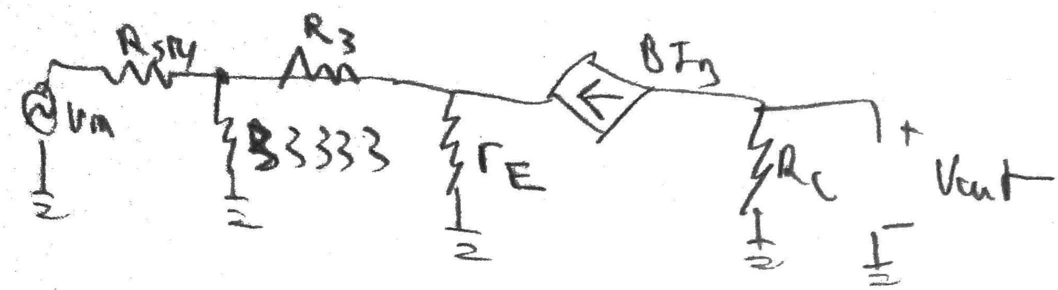
$g_m = \frac{B}{r_\pi} = .488$

$r_e = \frac{r_\pi}{101} = 2.2027$

C:




D:




E: $R_{sig} \to 0$ $R_L \to \infty$

$R_{in} = R_1 \| R_2 \| (R_3 + R_E) = 593.9\Omega$

$R_{out} = R_C = 800$

$V_{out} = -I_C \cdot R_C = -100 I_B \cdot 800 = -10.32$

$V_{in} = V_{R_3} + V_{RE} = I_B R_3 + (\beta+1) I_B \cdot r_e = .077$

$A_{vo} = \frac{V_{out}}{V_{in}} = -134.026$

F: $A_V = \frac{R_{in}}{R_{in}+R_{sig}} \cdot A_{vo} \cdot \frac{R_L}{R_L+R_{out}} = -95.6$