ECE 2C Final Exam

June 8 , 2010

Do not open exam until instructed to.

Closed book: Crib sheet and 2 pages personal notes permitted

There are 4 problems on this exam, and you have 3 hours.

Use any and all reasonable approximations (5% accuracy is fine.) , ***AFTER STATING and approximately Justifying them.***

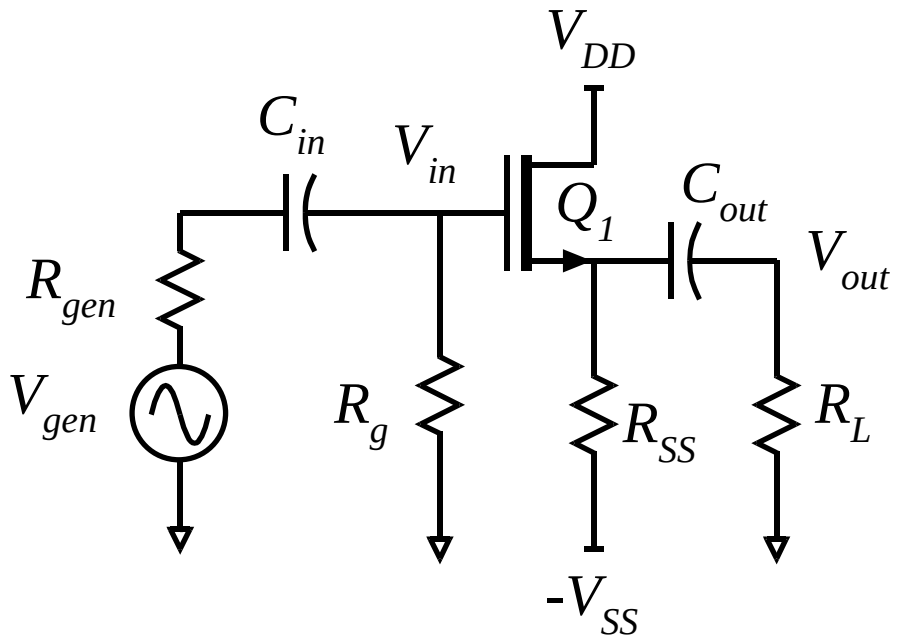
Name: _____

Problem	Points Received	Points Possible
1a		5
1b		5
1c		5
1d		5
1e		5
1f		10
2a		10
2b		10
2c		10
2d		10
3a		10
3b		10
3c		5
3d		5
3e		5
4a		5
4b		5
4c		5
4d		5
4e		5
4f		10
total		155

a

Problem 1, 40 points

You will be working on the circuit below:



Q1 is a velocity-limited FET, i.e. $I_d = (C_{ox} v_{sat} W_g)(V_{gs} - V_{th} - \Delta)(1 + \lambda V_{ds})$ where $(C_{ox} v_{sat} W_g)$=10 mA/V, $\lambda = 0.1\,\mathrm{V}^{-1}$, and $V_{th} + \Delta V$ =0.30 V.

+Vcc= +1.0 volts, -Vss= -1 Volts
Cin1 and Cout are very big and have negligible AC impedance.
RL=10 kOhm
Rgen=1 MOhm, Rg=10 MOhm

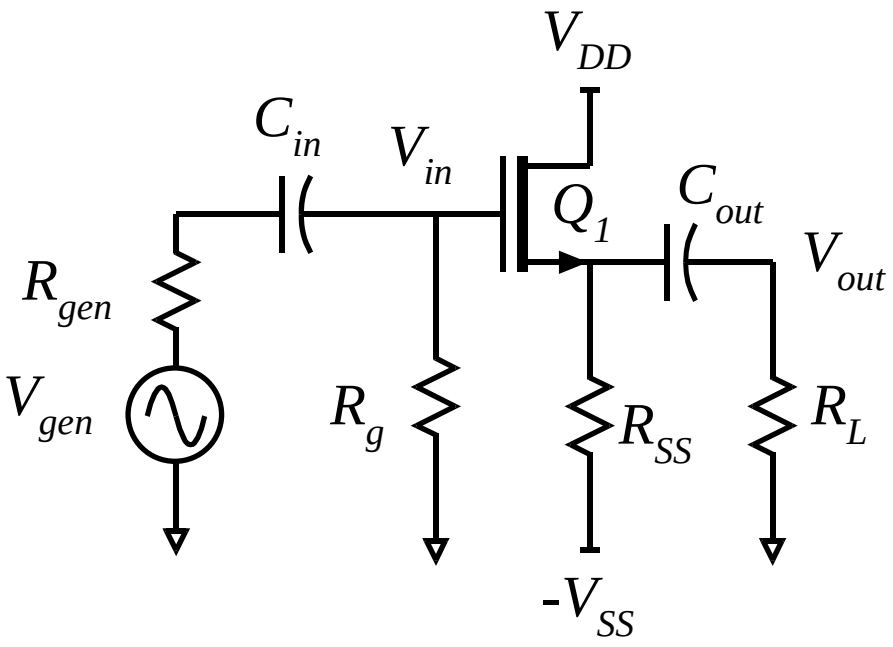
Part a, 5 points
DC bias.
Q1 is to be biased with 1 mA drain current.
Ignore λ while solving this part.

Find: Rss=_____
The DC voltage at the source of Q1. =_____

a

Part b, 5 points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes** and the DC currents through **ALL resistors**

Part c, 5 points

Find the small signal parameters of Q1. Use the constant-mobility model.

gm=_____
Rds=_____

Part d, 5 points

Replacing the transistor with its small-signal model, draw a small-signal equivalent circuit diagram for the amplifier. Give values for all elements on the diagram.

a

Part e, 5 points.

Find the small signal voltage gain (Vout/Vin) of Q1.

Vout/Vin=_____

a

Part f, 5 points

Find the *** amplifier *** input resistance, Vin/Vgen, and Vout/Vgen

Rin,amplifier =_____

Vin/Vgen= _____

(Vout/Vgen) = _____

Part g, 10 points

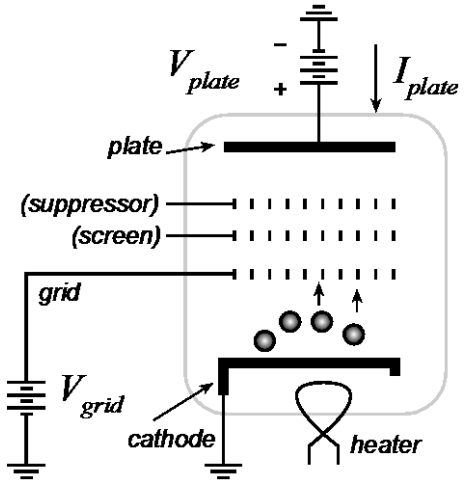
Now you must find the maximum signal swings. Find the output voltage due to the knee voltage and due to cutoff in Q1.

Cutoff of Q1; Maximum ΔVout resulting = _____

Knee voltage of Q1; Maximum ΔVout resulting = _____

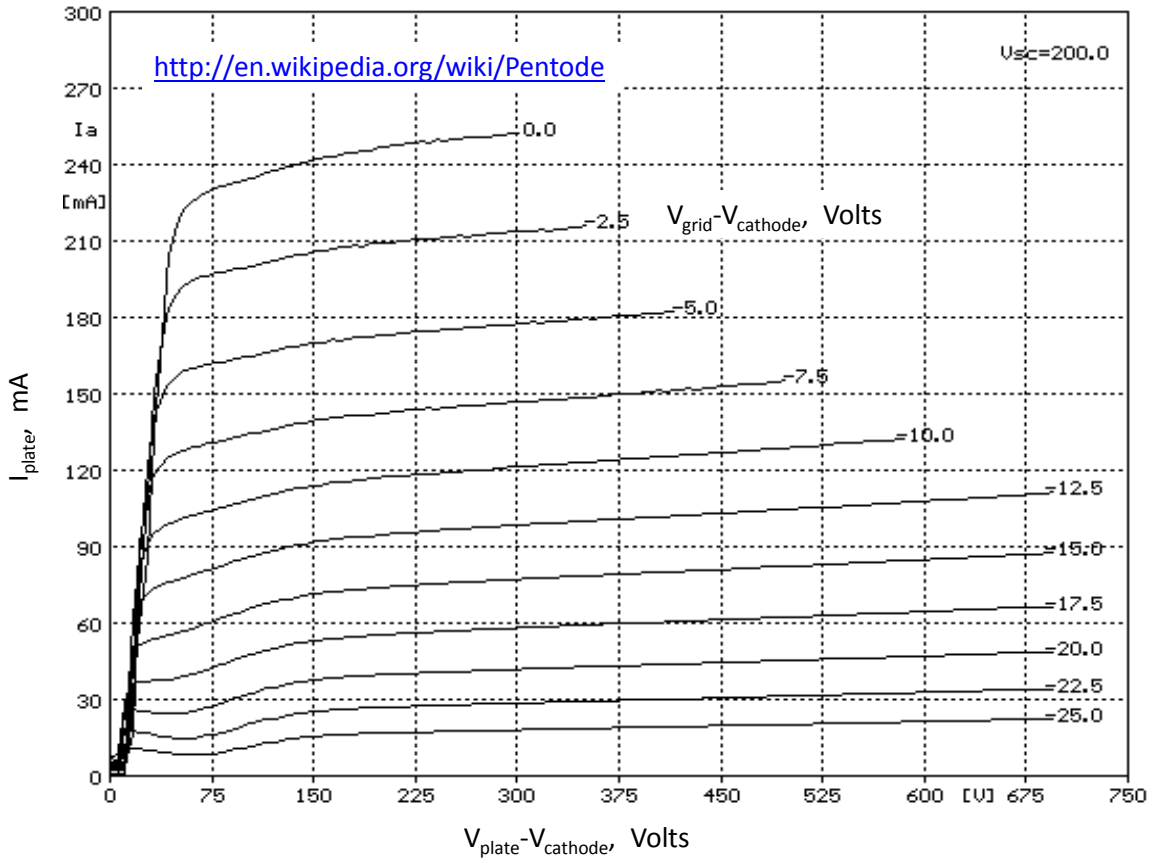
Problem 2, 40 points

Principles of small-signal analysis and active device modeling: To the right is a circuit diagram of a pentode vacuum tube. Current flows between cathode and plate under control of the voltage between the grid and the cathode. Don't worry about the suppressor and the screen.

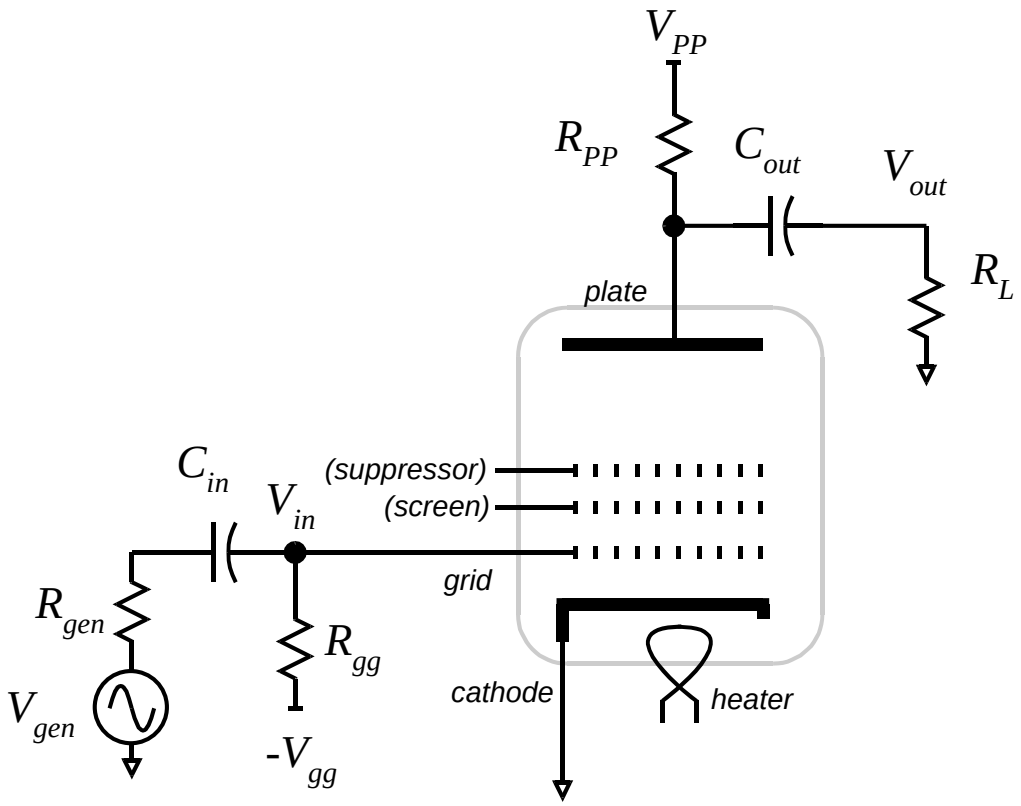


The plate current is plotted below as a function of plate-to-cathode and grid-to-cathode voltage.

Important: the grid current is nearly zero (is negligible).



Part a, 10 points



You must now work with the circuit above.

Vpp=600 Volts, Rgen=100 kOhm, Rgg=1MegOhm, RL=10 kOHm.
The Tube is to be biased at 120 mA plate current, and 300 Volts plate voltage.
Find the grid bias voltage -Vgg and the plate bias resistance Rpp.

-Vgg=_____ Rpp=_____

Part b, 10 points

Find the following:

The tube transconductance gm=_____

The tube AC small signal output resistance Rout,tube=_____

Part c, 10 points

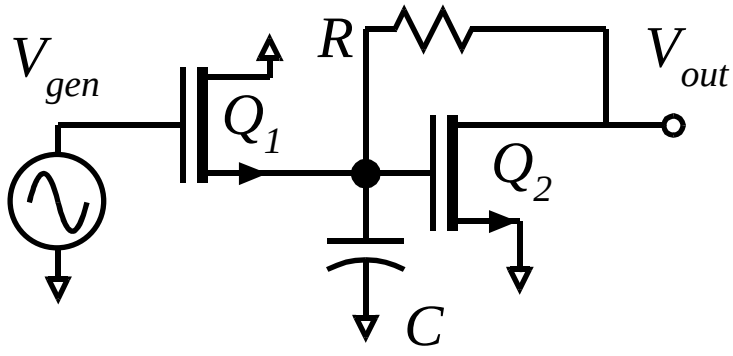
Draw an AC small signal equivalent circuit of the amplifier.

Part d, 10 points

Find the AC small signal voltage gain Vout/Vgen
Vout/Vgen =_____

Problem 3: 35 points

Nodal analysis and transistor circuit models



Ignore DC bias; you don't need it.

The transistors have zero C_{gs} and C_{gd}, and have transconductance g_{m1} and g_{m2}. Both have zero G_{ds}

Part a, 10 points

Draw an accurate small-signal equivalent circuit model of the circuit above.

Part b, 10 points

Using NODAL ANALYSIS, find the transfer function Vo(s)/Vgen(s)

The answer must be in standard form $\frac{V_o(s)}{V_{gen}(s)} = \left.\frac{V_o}{V_{gen}}\right|_{low-frequency-value} \times \frac{1+b_1 s+b_2 s^2+...}{1+a_1 s+a_2 s^2+...}$,

$\frac{V_o(s)}{V_{gen}(s)}$ =_____

Part c, 5 points

$g_{m1} = g_{m2} = 10$ mS. $R = 100$ Ohms. $C = 1$ pF.

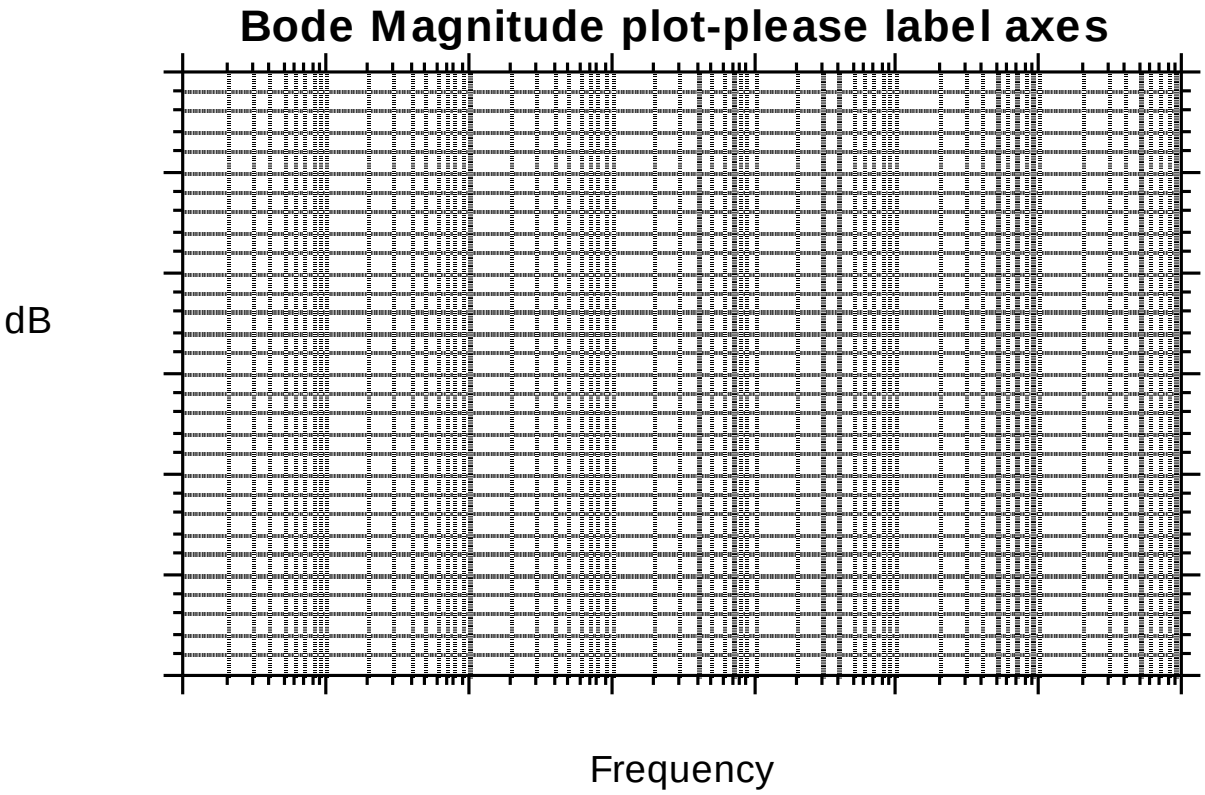
How many poles are there in the transfer function ?

Give its frequency / their frequencies:

$f_{p1} =$_____ , $f_{p2} =$_____, $f_{p3} =$_____....

Part d, 5 points

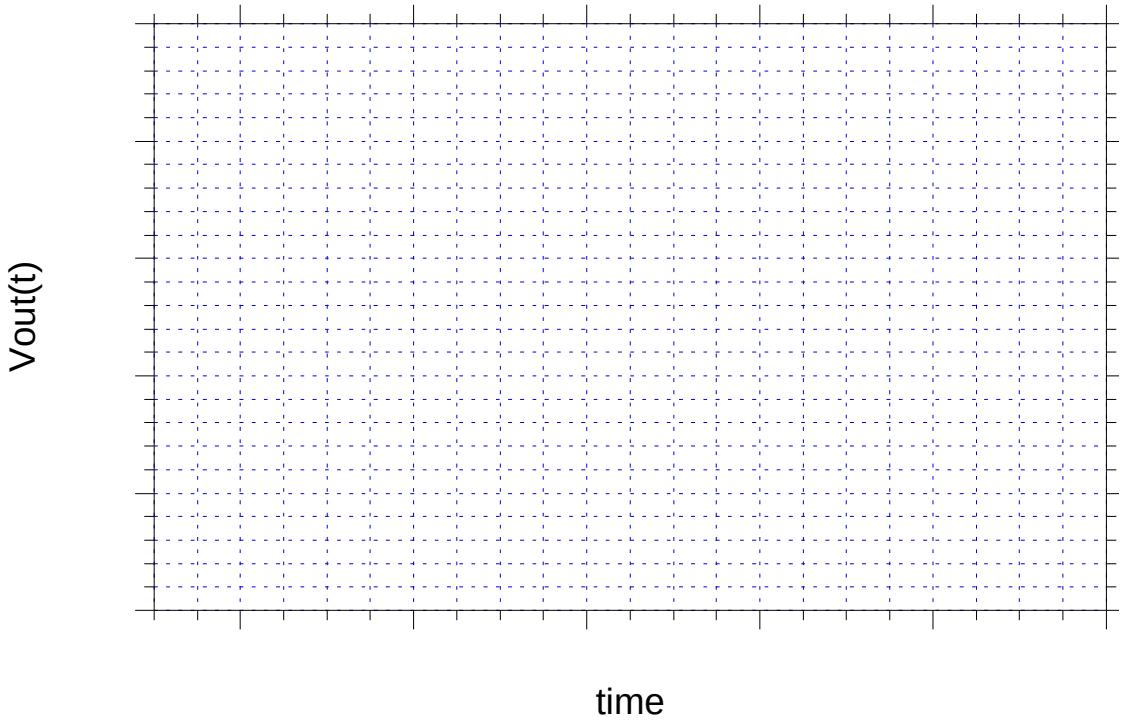
Make an accurate Bode plot of Vout/Vgen, labeling all slopes, and all key gain and frequency values.



Part e, 5 points

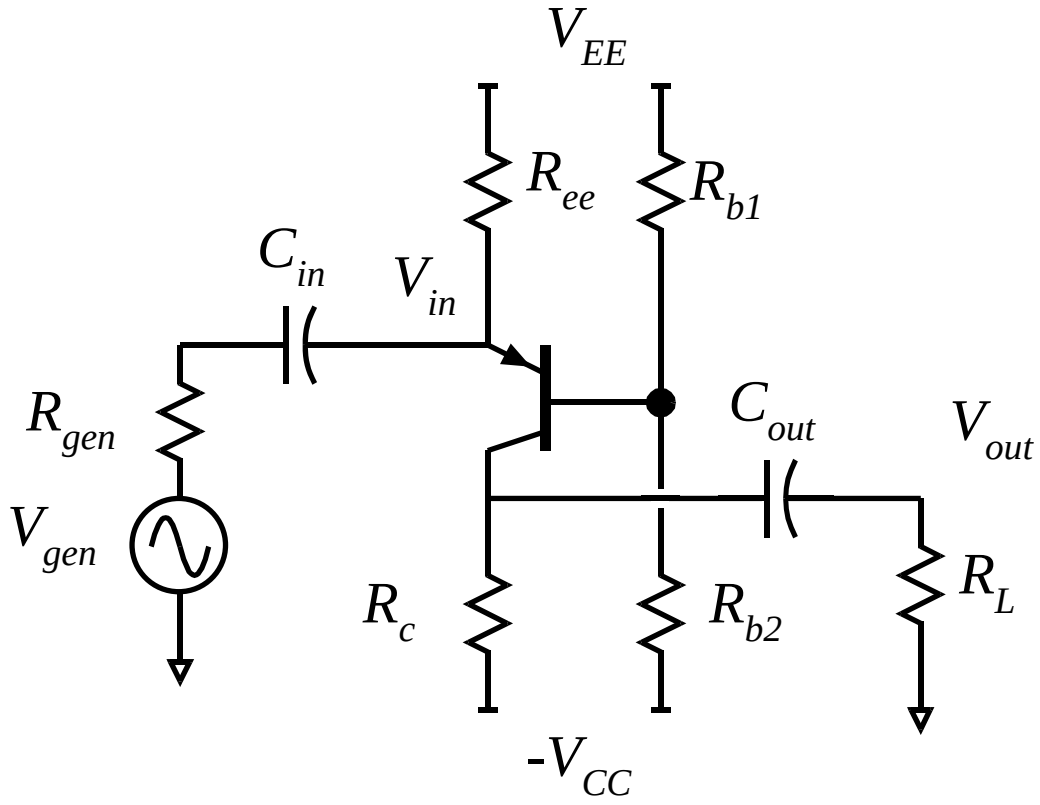
If Vgen(t) is a 1 mV step-function, find and ***accurately*** plot Vout(t). ***Be sure to label both axes and give units***.

Vout(t)=_____



Problem 4, 40 points

You will be working on the circuit below:



Q1 is a PNP transistor with $\beta = 100$ and $V_A = \infty$ Volts.
+Vee= +5.0 volts, -Vcc= -5 Volts
Cin1 and Cout are very big and have negligible AC impedance.
RL=10 kOhm
Rgen=100 Ohm,

Part a, 5 points

DC bias.

Q1 is to be biased with 5 mA emitter current. The collector is to be biased at -1 Volt and the emitter at +3 Volts. The DC current through Rb1 is to be 10 times the Q1 base DC current. Find Ree, Rb1, Rb2, and Rc

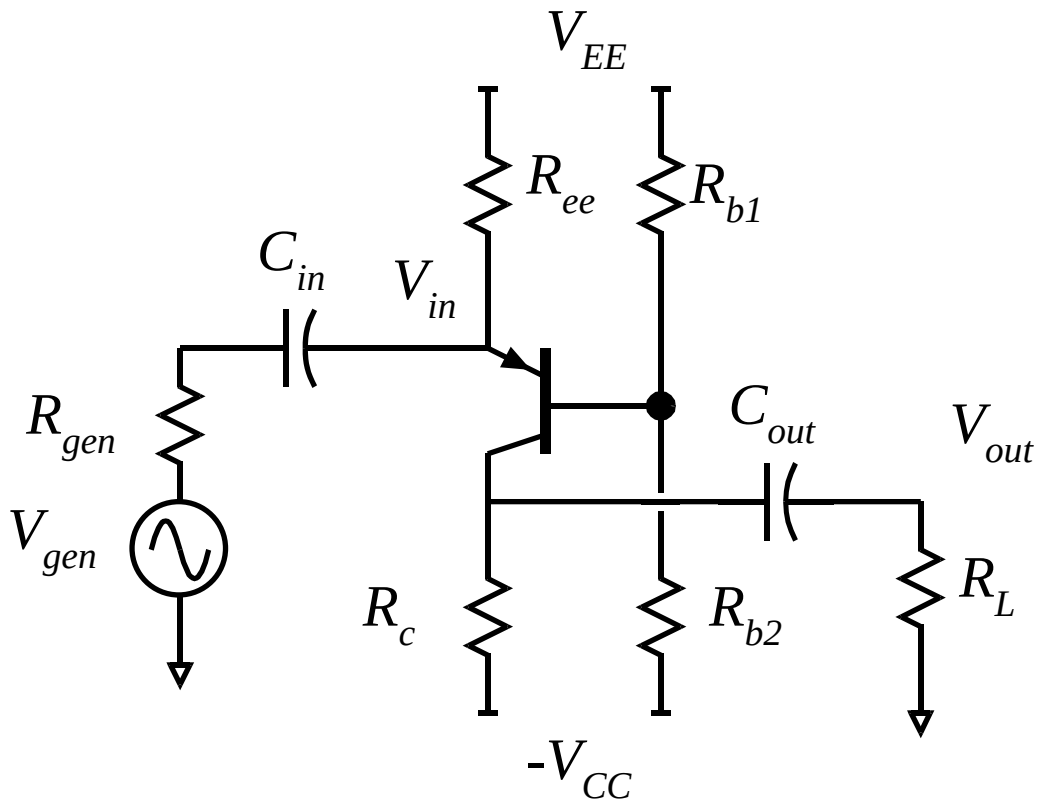
Ree=_____ Rb1=_____

Rb2=_____ Rc=_____

a

Part b, 5points

DC bias



On the circuit diagram above, label the DC voltages at **ALL nodes** and the DC currents through **ALL resistors**

Part c, 5 points

Find the small signal parameters of Q1.

gm=_____ Rbe=_____ Rce=_____

Part d, 5 points

Replacing the transistor with its small-signal model, draw a small-signal equivalent circuit diagram for the amplifier. Give values for all elements on the diagram.

Part e, 5 points.

Find the small signal voltage gain (Vout/Vin) of Q1.

Vout/Vin=_____

Part f, 5 points

Find the *** amplifier *** input resistance, Vin/Vgen, and Vout/Vgen

Rin,amplifier =_____

Vin/Vgen= _____

(Vout/Vgen) = _____

Part g, 10 points

Now you must find the maximum signal swings. Find the output voltage due to the knee voltage and due to cutoff in Q1.

Cutoff of Q1; Maximum ΔVout resulting = _____

saturation of Q1; Maximum ΔVout resulting = _____