ECE137B Final Exam

There are 6 problems on this exam and you have 3 hours

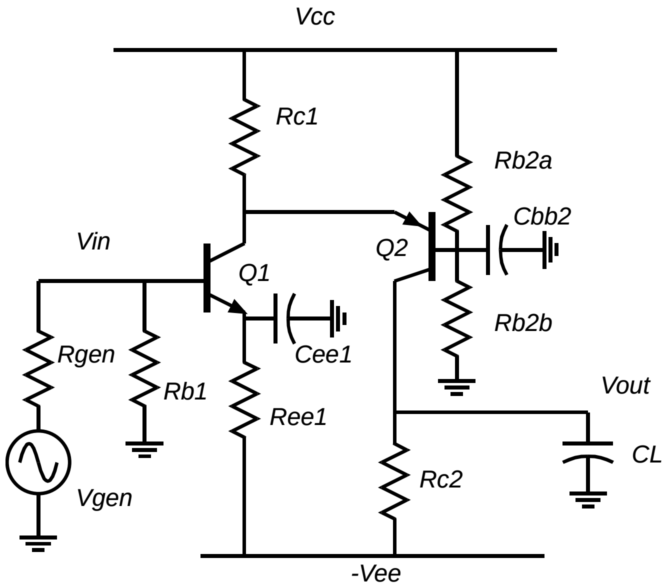
Do not open this exam until told to do so
Show all work:
Credit will not be given for correct answers if supporting work is not shown.
Class Crib sheets and 4 pages of your own notes permitted.
Don't panic.

Time function	LaPlace Transform
$\delta(t)$	1
$U(t)$	1/s
$e^{-\alpha t}U(t)$	$\frac{1}{s+\alpha}$
$e^{-\alpha t}\cos(\omega_d t)U(t)$	$\frac{s+\alpha}{(s+\alpha)^2+\omega_d^2}$
$e^{-\alpha t}\sin(\omega_d t)U(t)$	$\frac{\omega_d}{(s+\alpha)^2+\omega_d^2}$

Name: ___________________________________

Problem 1, 20 points
transistor circuit analysis

part a, 5 points



In the circuit, the power supplies are +/- 10 volts. The transistors have beta=1000, ft=1 GHz, and Ccb=0.5 pF. CL=1 pF. Va=infinity.

Cee1 and Cbb2 are very large (AC short-circuits)

Rgen=1kOhm, Rb1=10 kOhm

Rb2a and Rb2b are chosen to bias the base of Q2 at +4.3 volts.

Q1 and Q2 are each biased at 1 mA emitter current.

Rc2 is chosen to set the DC output voltage to zero volts.

Find Ree1, Rc1, Rc2

Ree1=___________________ Rc1=___________________ Rc2=___________________

Part b, 5 points

Find the mid-band value of Vout/Vgen.
Vout/Vgen=________________________

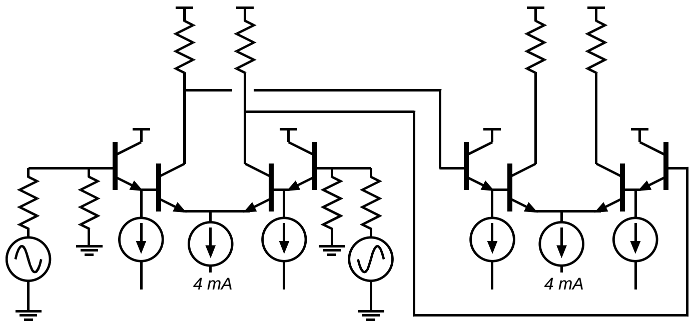
Part c, 10 points

Find Cpi of transistors Q1 and Q2. Give the frequency, in Hz (not rad/sec), of the 3 major poles in the transfer function.

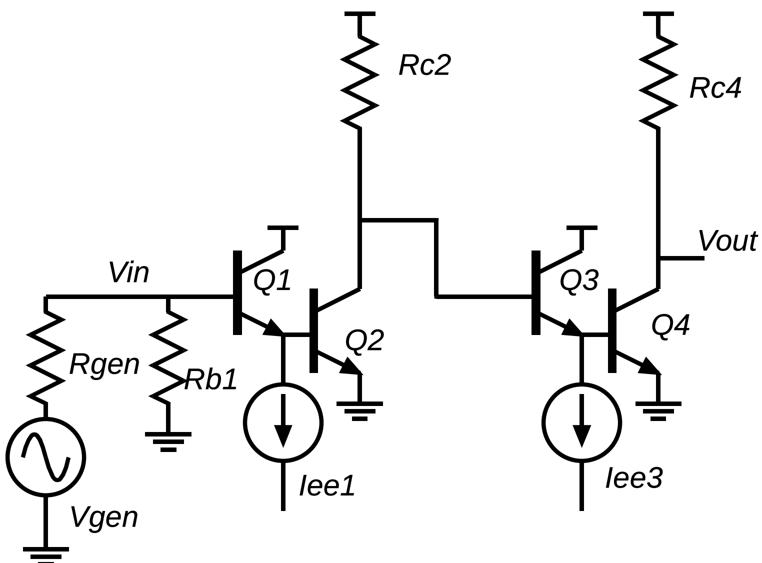
Cpi1=____________________ Cpi2=____________________

fp1=____________________ fp2=____________________ fp3=____________________

Problem 2, 20 points
method of first-order time constants



A basic differential video amplifier is shown on the left. This circuit is fully differential, and so can be analyzed by the half-circuit method, where the connected emitters of the differential pairs become virtual grounds.



The circuit we therefore analyze is to the left. This is an AC equivalent circuit: It does not represent the DC.

All transistors have ft=500 MHz and Ccb=1 pF.
Beta=infinity, Va=infinity

Rgen=Rb1=50 Ohms.

Q1 and Q3 are each biased at 1 mA. Q2 and Q4 are each biased at 2 mA.

Rc2 and Rc4 are 100 Ohms

<u>Part a, 5 points</u>
Find Cpi of Q1-Q4.
Cpi1=______________________ Cpi2=______________________
Cpi3=______________________ Cpi4=______________________

Part b, 15 points

Using the method of time constants, find the dominant time constant a_1 of the transfer function $V_{out}(s)/V_{gen}(s)$. Give the components of a_1 due to each transistor capacitance.

a_1 =____________________ seconds

component of a_1 due to Ccb1=____________________________________ seconds

component of a_1 due to Ccb2=____________________________________ seconds

component of a_1 due to Ccb3=____________________________________ seconds

component of a_1 due to Ccb4=____________________________________ seconds

component of a_1 due to Cpi1=____________________________________ seconds

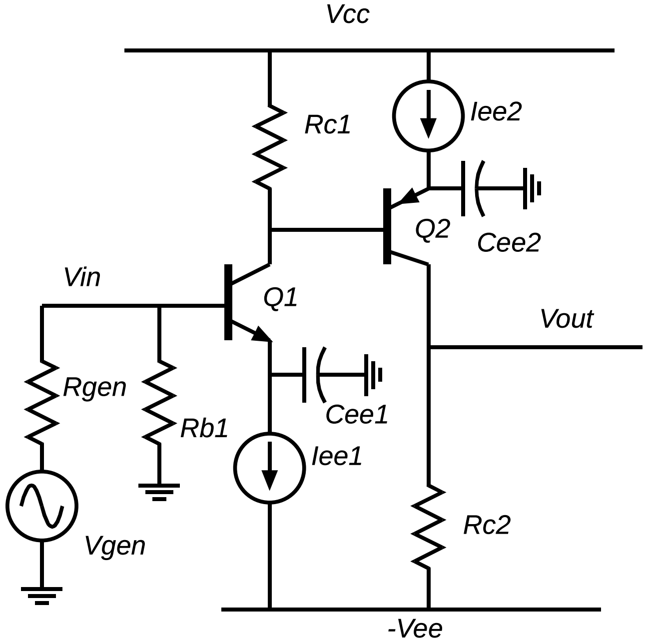
component of a_1 due to Cpi2=____________________________________ seconds

component of a_1 due to Cpi3=____________________________________ seconds

component of a_1 due to Cpi4=____________________________________ seconds

Problem 3, 20 points

method of first-order and second-order time constants



Q1 has ***Cbe=10 pF, Ccb=1 pF***.
Beta=infinity, Va=infinity.

Q1 has ***Cbe=0 pF, Ccb=1 pF***.
Beta=infinity, Va=infinity.

Cee1 and Cee2 are very large (AC short-circuits)

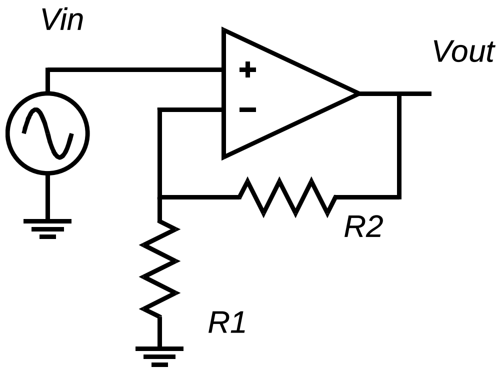
The supplies (Vcc and -Vee) are +/- 10 volts.
Iee1=1 mA. Iee2=2 mA.

Rgen=Rb1=50 Ohms.
Rc1=100 Ohms. Rc2=400 Ohms.

Use the method of time constants to find the frequencies of the first two poles of the transfer function Vout(s)/Vgen(s).

Problem 4 10 points

negative feedback



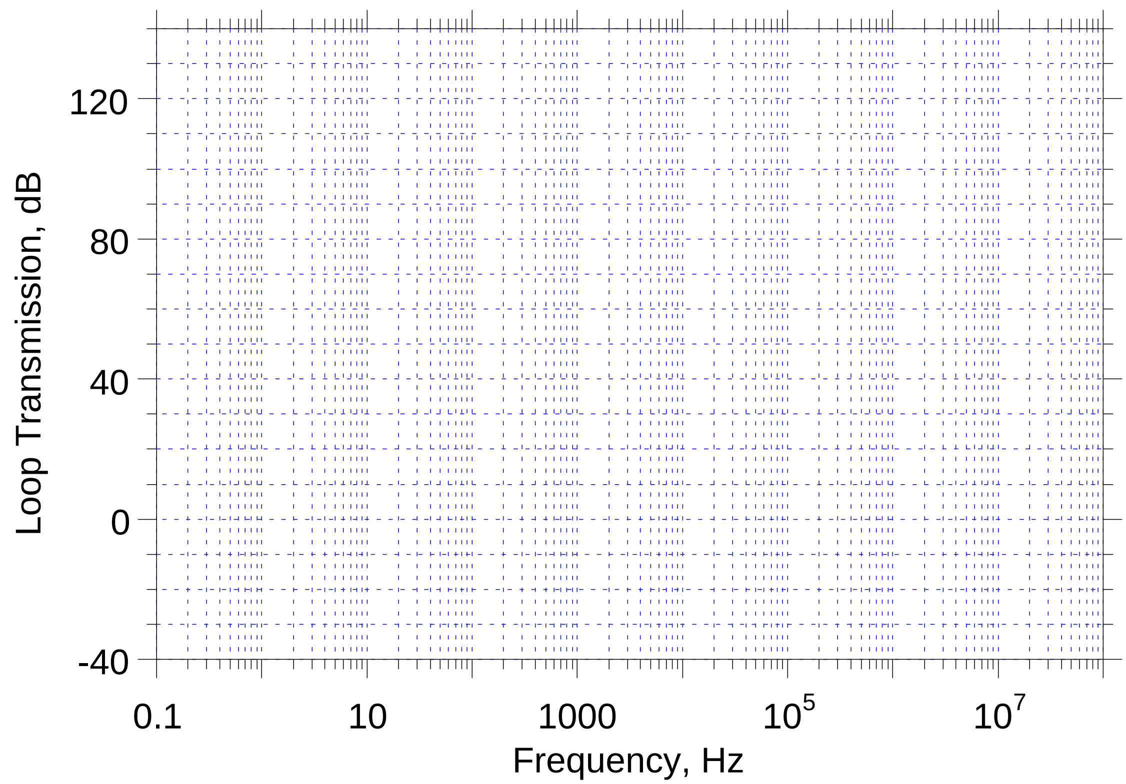
The amplifier has a differential gain of 10^7. R1=1 kOhm, R2=19 kOhm. The op-amp has infinite differential input impedance and zero differential output impedance.

The differential amplifier has poles in its open-loop transfer function at 20 Hz and 100 kHz. .

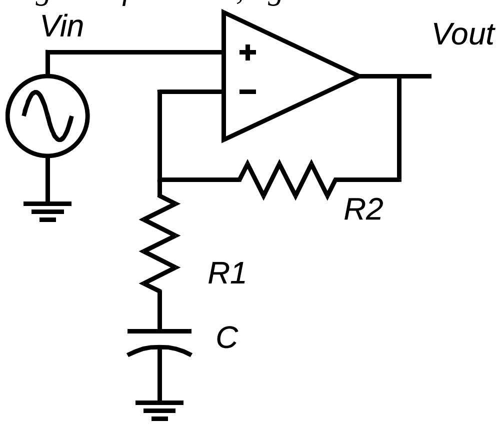
Using the Bode plot below, determine the following

Loop bandwidth=_______________ phase margin=___________________

Vout/Vgen at DC=____________________



Problem 5 15 points
negative feedback, again



The differential amplifier has infinite differential input impedance and zero output impedance. Its low-frequency gain is 10^6, and it has a single pole in its transfer function at 2 Hz.

R1=100 Ohms. R2=9.9 kOhm.
C=1.59 microfarads.

<u>Part a, 5 points</u>

Find the feedback factor $\beta(s)$, using standard form $\beta(s)=\beta_{dc}\dfrac{1+b_1 s+b_2 s^2+...}{1+a_1 s+a_2 s^2+...}$

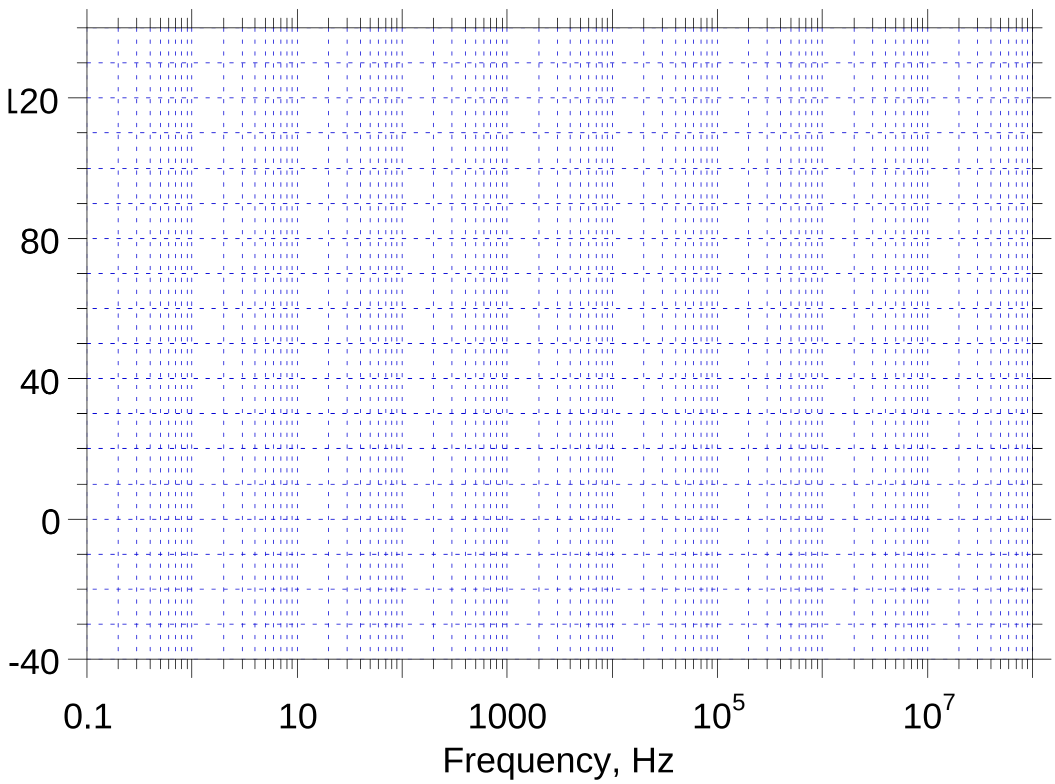
$\beta(s)=$ ________________________

Part b, 10 points

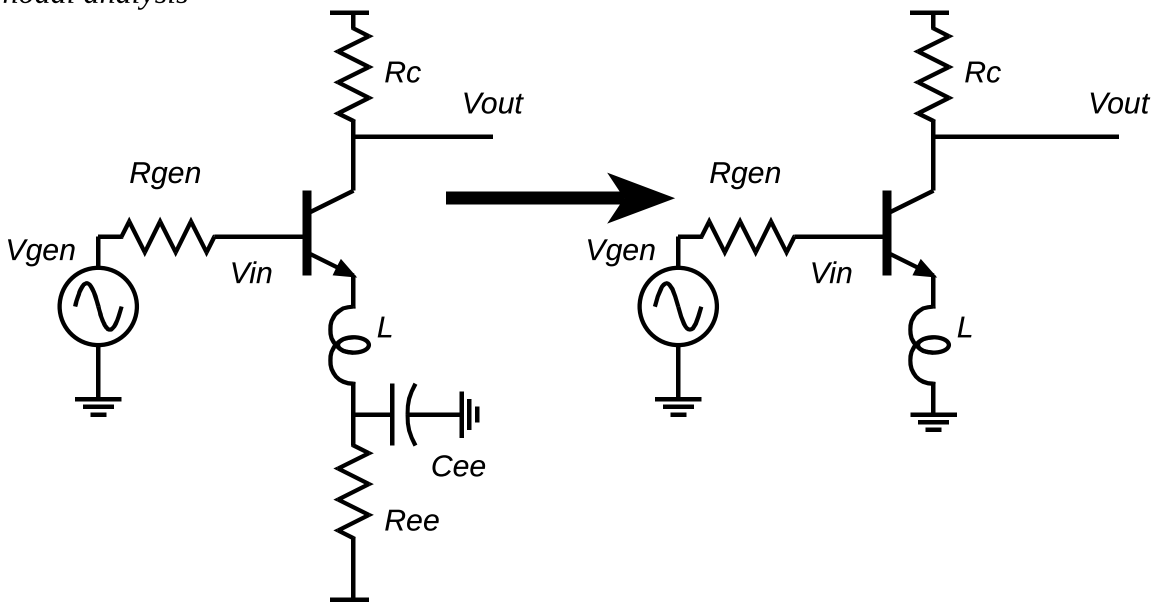
Use the Bode plot below to plot the ***closed loop transfer function*** A_{CL}, the differential gain A_d, and the inverse of the feedback factor $1/\beta$. List all the poles and zero frequencies of A_{CL}

Poles in Acl at frequencies ____ Hz

Zeros in Acl at frequencies ____ Hz



Problem 6 15 points
nodal analysis



Inductance, often present in the emitter lead of a common-emitter amplifier, can have a serious effect on high frequency response. Working from the small-signal equivalent ***circuit on the right***, with Rgen=***zero*** Ohms, Rc=100 Ohms, L=1 nH, re=26 Ohms, Cbe=1 pF, Ccb= ***0pF***, beta=infinity, Va=infinity, find Vout/Vgen by nodal analyis. Give the answer in standard form $\frac{V_{out}(s)}{V_{gen}(s)} = \left.\frac{V_{out}}{V_{gen}}\right|_{DC} \frac{1+b_1 s+b_2 s^2+...}{1+a_1 s+a_2 s^2+...}$

Vout(s)/Vgen(s)=______________________________________