American University of Beirut
Department of Electrical and Computer Engineering
EECE 311 – Electronic Circuits
Spring 2014
Midterm – March 21, 2014
Open Book – 120 minutes

NAME:_____ ID Number: _____

- All questions are equally graded
- **PENALTY** is four-to-one (four wrong answers cancel one correct answer, one to three wrong answers have no effect)
- Grading is based on the answers marked on the SCANTRON sheet only.
- There are **28** questions and **8** pages in this exam.
- Unless otherwise specified, neglect the effect of V_A (channel-length modulation in MOSFETs, or base-width modulation in BJTs)
- Assume $V_T = 25$ mV and $V_{BE(ACTIVE)} = 0.7$ V.

1. Find the exact 3-dB frequency (in kHz) for the amplifier with the following transfer function. Assume $A = 8$.

$$F_H(s) = \frac{1 - \frac{s}{3\times10^5}}{\left(1 + \frac{s}{A\times10^4}\right)}$$

a) 15.8 b) 13.7 c) 8.2 d) 10.0 e) 11.8

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2. Find the 3-dB frequency (in kHz) for the amplifier with the following transfer function. Use the most appropriate method to obtain a *quick* answer. Assume $A = 2$.

$$F_H(s) = \frac{1 - \frac{s}{3\times10^6}}{\left(1 + \frac{s}{A\times10^4}\right)\left(1 + \frac{s}{9\times10^5}\right)\left(1 + \frac{s}{4\times10^6}\right)}$$

a) 3.2 b) 4.8 c) 6.4 d) 8.0 e) 1.6

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3. Consider the amplifier gain function shown below. When the input voltage is $v_i(t) = 7\sin(\omega t)$ mV with $\omega = 2\pi\times3000$ rad/sec, the output is $v_o(t) = X\sin(\omega t + \phi)$ mV. Find X (in mV).

$$A(s) = \frac{1000}{\left(1 + \frac{s}{3\times10^3}\right)}$$

a) 2123.2 b) 1625.5 c) 1313.2 d) 1100.2 e) 946.2

4. In the previous problem, find ϕ (in degrees).
a) –81.0 b) –79.2 c) –82.2 d) –72.3 e) –76.6

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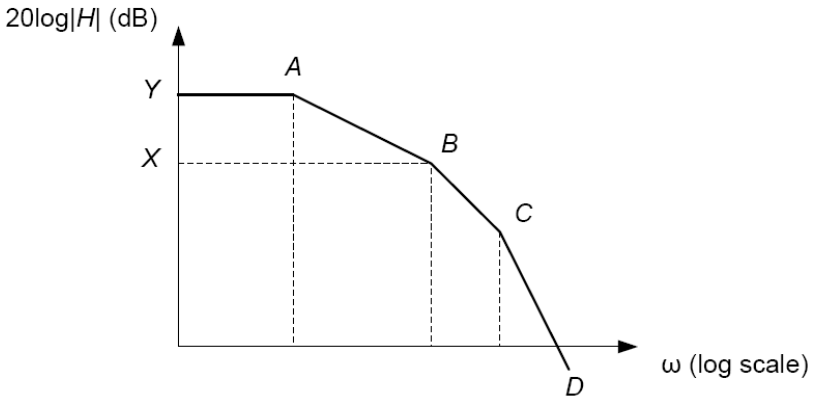
The asymptotic magnitude Bode plot of an amplifier with three poles and no zeros is shown below.



5. Find the slope of segment CD in dB/decade.
a) –30 b) –10 c) –40 d) –20 e) –60

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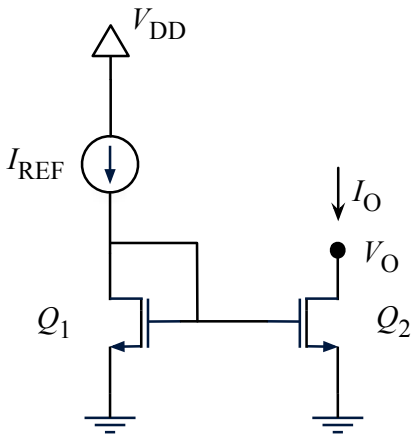
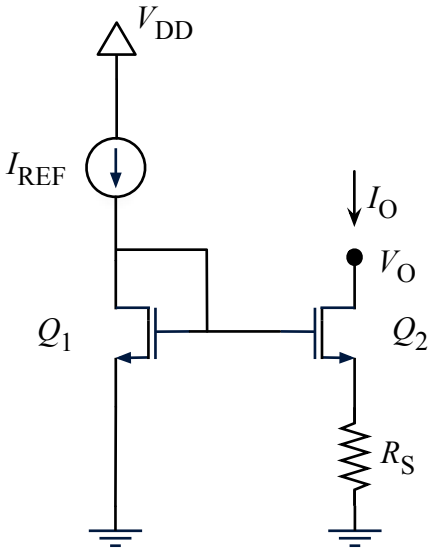
The reference current in the circuit shown below is 60 μA. Assume V_{DD} = 2 V and that $(W/L)_1$ for MOSFET Q_1 is 10, while $(W/L)_2$ for MOSFET Q_2 is 15.
For the two MOSFETs, k'_n = 400 μA/V^2, and V_t = 0.5 V.



6. What is the minimum value of output voltage V_O (in V) to maintain proper current source operation?
a) 0.200 b) 0.245 c) 0.173 d) 0.155 e) 0.346

7. Find the output current I_O (in μA) when a resistor R_S = 2 kΩ is inserted between the source of Q_2 and ground (as shown below). All other parameters are unchanged.



a) 47.4 b) 33.6 c) 31.6 d) 36.4 e) 40.4

8. Assume that after adding the resistor R_S = 2 kΩ between source of Q_2 and ground, the reference current was adjusted such that for Q_2, r_{o2} = 20 kΩ and g_{m2} = 0.2 mA/V. Find the output resistance (in kΩ) of the current source.
a) 42 b) 46 c) 34 d) 38 e) 30

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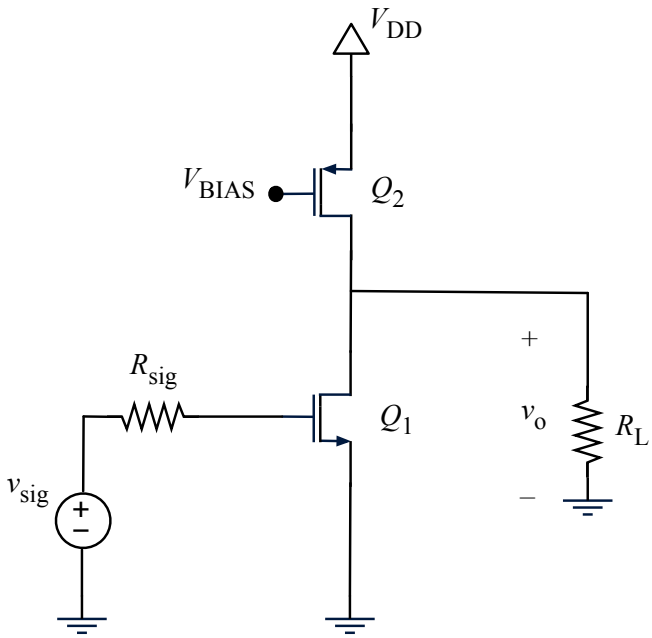
In the circuit shown below, assume that for the MOSFETS, the small-signal parameters are: $g_{m1} = 4$ mA/V, $g_{m2} = 2$ mA/V, $r_{o1} = 34$ kΩ, and $r_{o2} = 48$ kΩ. The signal and load resistances are $R_{sig} = 5$ kΩ and $R_L = 18$ kΩ. For high-frequency analysis, the MOSFETs have $C_{gs} = 2$ pF and $C_{gd} = 0.6$ pF.



9. Find the OCTC resistance seen by a capacitor connected between the output node and ground (in kΩ).
a) 7.91 b) 8.82 c) 9.45 d) 9.98 e) 10.3

10. Apply Miller's theorem to find the *total* capacitance (in pF) that appears between the output node and ground.
a) 1.01 b) 1.62 c) 1.22 d) 0.81 e) 0.41

11. Use Miller's approximation to find an estimate of ω_{3dB}, the 3-dB frequency of $|V_o/V_{sig}|$, in Mrad/s. Assume that ω_{3dB} is determined by a single dominant pole at the input.
a) 10.89 b) 8.67 c) 6.45 d) 7.91 e) 23.45

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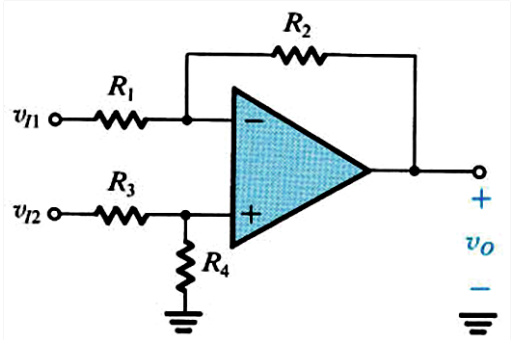
12. In the circuit shown below, the opamp is ideal. Assume $R_2 = R_4 = 10$ kΩ, $R_1 = 1$ kΩ, and $R_3 = 1.02$ kΩ. Calculate the Common Mode Rejection Ratio (in dB) of this difference amplifier.



a) 36.8 b) 60.8 c) 54.8 d) 48.8 e) 42.8

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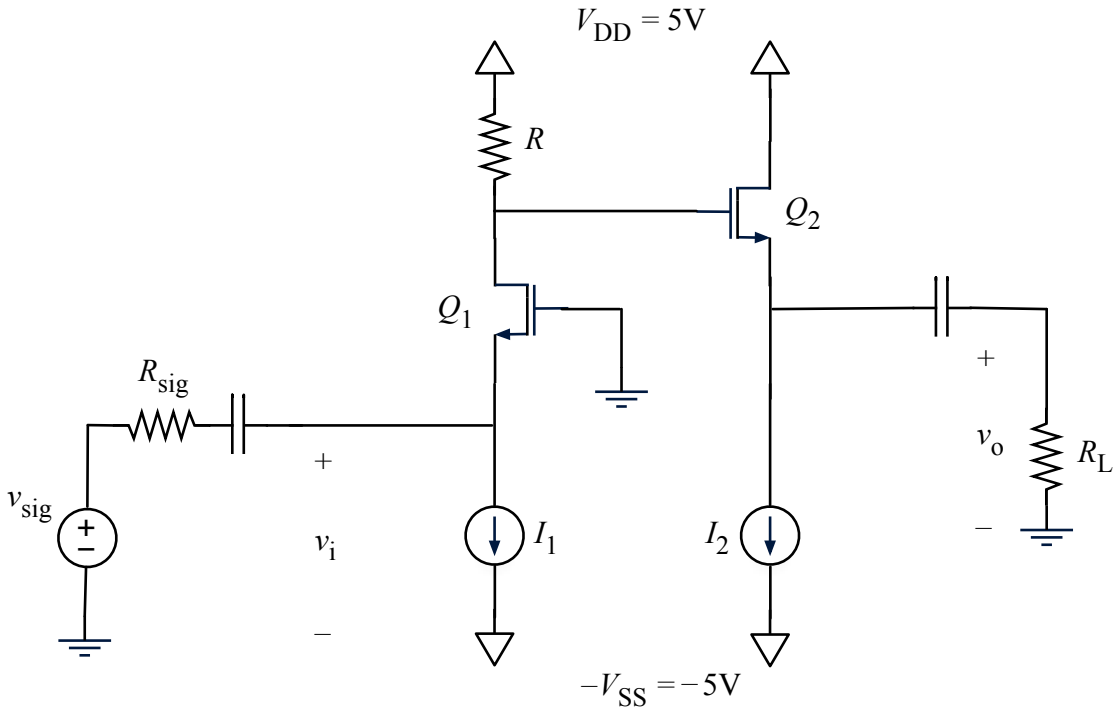
In the circuit shown below, the transistors are biased in the saturation region using two *ideal* current sources: $I_1 = 0.1$ mA, and $I_2 = 2I_1$. The two large capacitors shown are open-circuits at DC, but can be considered as short-circuits for all signal frequencies of interest, and during OCTC calculations. The amplifier comprises two stages. The first stage is built around MOSFET Q_1, while the second stage is built around MOSFET Q_2.
Assume $R_{sig} = R_L = 2$ kΩ. The two transistors have $k'(W/L) = 1$ mA/V^2.



13. The Q_1 stage is a common-… stage, and the Q_2 stage is a common-… stage

a) source, drain
b) gate, source
c) source, source
d) drain, gate
e) gate, drain

14. Find the value of the resistor R (in kΩ) to make the DC voltage at the gate of Q_2 equal to *zero* Volt.
a) 12.5 b) 10 c) 50 d) 25 e) 20

15. Find the small-signal voltage gain of the Q_2 stage, v_o/v_{g2} (in V/V).
a) 0.558 b) 0.641 c) 0.667 d) 0.717 e) 0.739

16. Assume in this question only that $R = 22$ kΩ. Find the small-signal voltage gain of the Q_1 stage, v_{g2}/v_i (in V/V).
a) 22.0 b) 9.8 c) 13.9 d) 15.6 e) 19.7

17. Find the input resistance of the amplifier, R_{in} (in kΩ).
a) 1.12 b) 1.00 c) 2.24 d) 1.58 e) 1.41

18. Find the output resistance of the amplifier, R_{out} (in Ω).
a) 1000 b) 791 c) 707 d) 1581 e) 1118

19. Find the OCTC resistance seen by C_{gs1} (in Ω).
a) 883 b) 667 c) 1056 d) 828 e) 717

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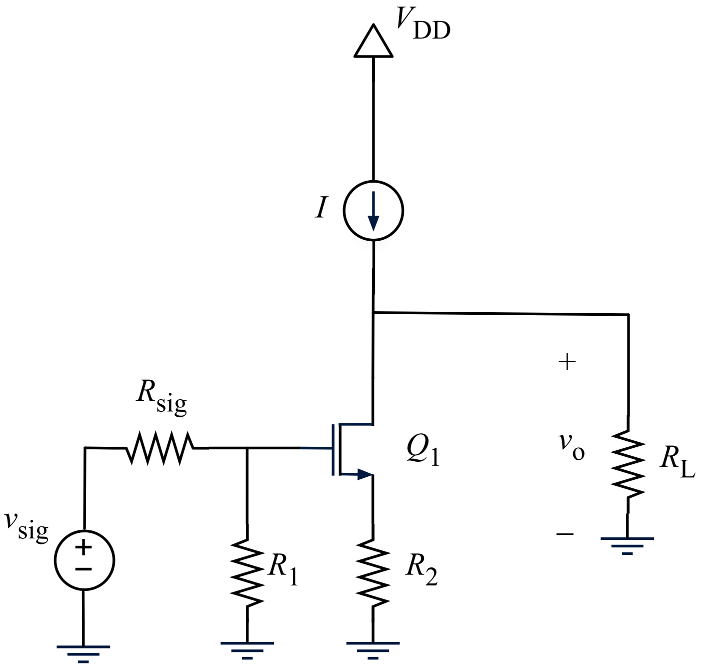
Assume in the circuit shown below that g_m = 1.4 mA/V, r_o = 20 kΩ, R_{sig} = 50 kΩ, R_L = 48 kΩ, R_2 = 2 kΩ, and R_1 = 150 kΩ. The current source is ideal.



20. Find the low-frequency small-signal voltage gain v_o/v_{sig} (in V/V).
a) –9.22 b) –5.73 c) –8.00 d) –9.98 e) –11.39

21. Find the OCTC resistance seen by a capacitor connected between the output node and ground (in kΩ).
a) 21.8 b) 29.7 c) 33.9 d) 41.5 e) 36.6

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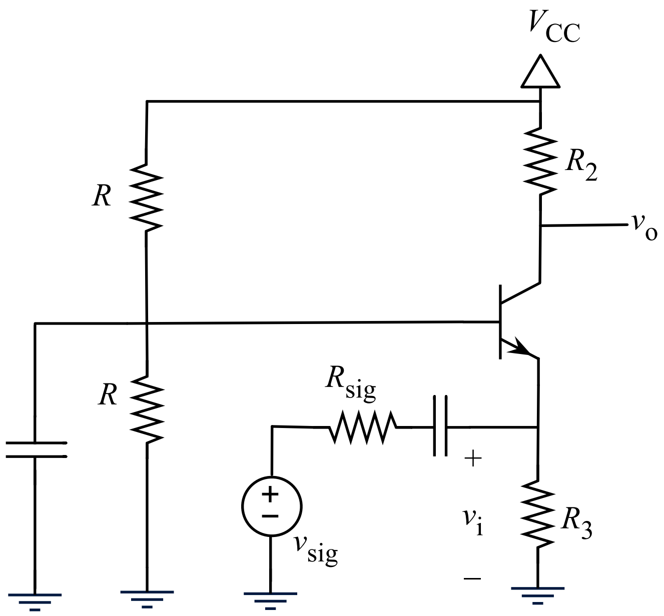
For the circuit shown below, the BJT has $r_o = 25\ \text{k}\Omega$ and *very large* β. The resistor values are $R = 10\ \text{k}\Omega$, $R_2 = 1\ \text{k}\Omega$, $R_3 = 3\ \text{k}\Omega$, and $R_{sig} = 2\ \text{k}\Omega$. Assume $V_{CC} = 3$ V. The two large capacitors shown are open-circuits at DC, but can be considered as short-circuits for all signal frequencies of interest, and during OCTC calculations.



22. Find g_m of the BJT (in mA/V).
a) 8.00 b) 6.40 c) 32.00 d) 16.00 e) 10.67

For the following two problems assume that g_m= 30 mA/V.

23. Find the OCTC resistance seen by C_π (in Ω).
a) 20.5 b) 89.7 c) 49.3 d) 33.6 e) 25.5

24. Find the transconductance of the amplifier i_o/v_i (in mA/V). Assume that a load resistance $R_L = 5\ \text{k}\Omega$ is connected across the output. The current i_o flows in the resistor R_L.
a) 1.62 b) 3.23 c) 4.85 d) 6.46 e) 8.07

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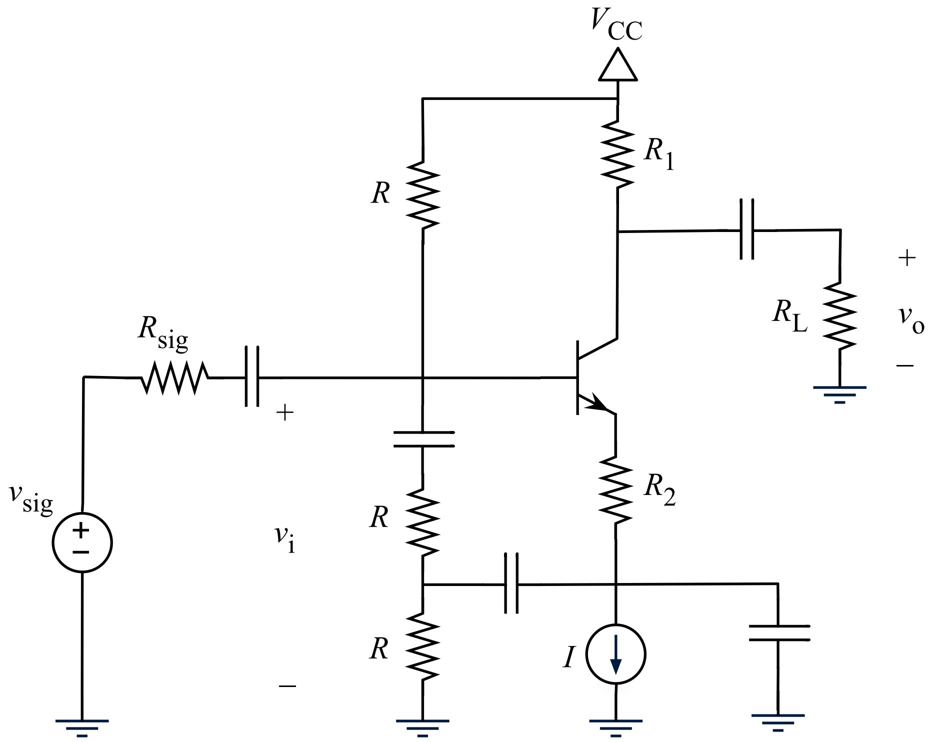
In the BJT amplifier circuit shown below, the device is biased using an ideal DC current source I = 2 mA, and has β = 60. The resistor values are: R = 60 kΩ, R_1 = 100 kΩ, R_2 = 2.0 kΩ, and R_L= 50 kΩ. The five capacitors shown are open-circuits at DC, but can be considered as short-circuits for all signal frequencies of interest.



25. This amplifier is a common-… stage.

a) gate b) drain c) source d) emitter e) base

26. Find the voltage gain v_o/v_i in (V/V).

a) –10.91 b) –31.86 c) –25.76 d) –21.61 e) –16.29

27. Find the output resistance, R_o (in kΩ). Assume in this question only that V_A = 25 V, and that Early effect does not affect the DC analysis (i.e. $I_C = I_S \exp(V_{BE}/V_T)$).

a) 85.0 b) 87.5 c) 82.2 d) 74.5 e) 79.0

28. Find R_{sig} (in kΩ) if v_i/v_{sig} = 0.6.

a) 14.40 b) 16.07 c) 17.54 d) 12.66 e) 10.23

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