# American University of Beirut

**Department of Electrical and Computer Engineering**

EECE 310 – Electronics

Quiz 2 – December 19, 2009

Closed Book – *No Programmable Calculators*

90 minutes

Penalty is 5 to 1

(1 to 4 wrong answers do not result in a penalty; 5 to 9 wrong answers cancel one correct answer; 10 to 14 wrong answers cancel two correct answers; and so on)

Name: ______________________________ ID number: ________________

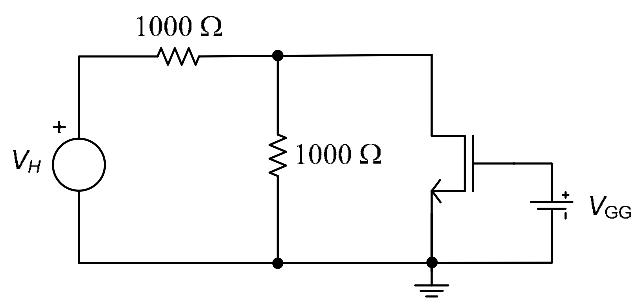
Two voltage amplifiers are cascaded to amplify the voltage signal of a source $v_i$ and deliver it to a load $R_L$ = 50 kΩ.
The first amplifier is modeled by an input resistance $R_i$ = 160 kΩ, output resistance $R_o$ = 10 kΩ, and open-circuit voltage gain $A_{vo}$ = 100 V/V.
The second amplifier is modeled by $R_i$ = 20 kΩ, output resistance $R_o$ = 40 kΩ, and $A_{vo}$ = 30 V/V.

1. Find the voltage gain $v_o/v_i$ (in V/V), where $v_o$ is the voltage across $R_L$.
a) 1000 b) 1667 c) 1429 d) 1250 e) 1111

2. Considering the two cascaded amplifiers as one equivalent amplifier, what is the input resistance (in kΩ) of this equivalent amplifier?
a) 100 b) 120 c) 140 d) 160 e) 180

3. Considering the two cascaded amplifiers as one equivalent amplifier, what is the output resistance (in kΩ) of this equivalent amplifier?
a) 40 b) 50 c) 10 d) 20 e) 30

4. In the circuit shown below, $V_H$ is a small voltage not exceeding a few milliVolts. The MOSFET parameters are $V_{t0}$ = 0.8 V and $k'W/L$ = 0.5 mA/V$^2$.
Find the ratio $V_{DS}/V_H$ when $V_{GG}$ = 6.3 V.
a) 0.15 b) 0.17 c) 0.23 d) 0.21 e) 0.19



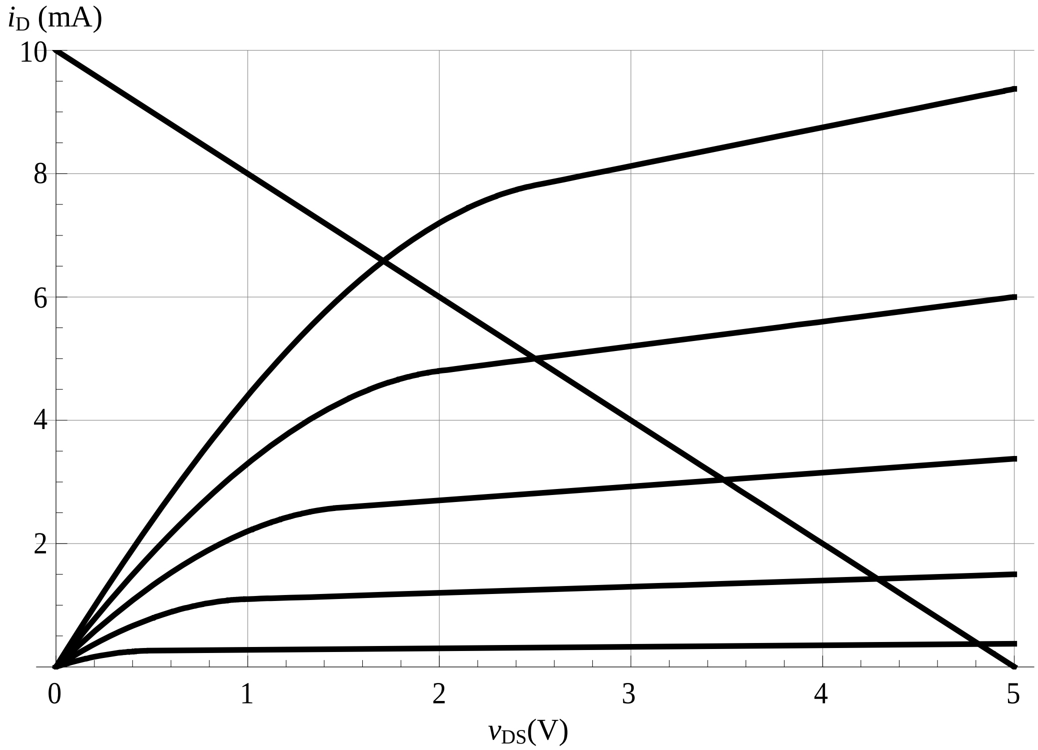



**Figure A**

The MOSFET whose $i_D - v_{DS}$ characteristics are shown in Figure A is to be biased at $V_{DS}$ = 3 V, $I_D$ = 4 mA. The curves correspond to the following values of $V_{GS}$: 1.5, 2, 2.5, 3, and 3.5 V. The load line is also shown in the figure.

5. Estimate the value of $V_{GS}$ (in V) at the bias point.

a) 3.15 b) 1.75 c) 2.25 d) 3.25 e) 2.75

6. Find the peak-to-peak variation in drain current (in mA) if the peak-to-peak variation in $v_{DS}$ is 1 V.

a) 2 b) 1 c) 0.5 d) 4 e) 3

7. Estimate the value of the drain-to-source resistance $r_{DS}$ (in Ohms) for small $v_{DS}$ in the triode region, when $V_{GS}$ is 3.5 V.

a) 800 b) 1000 c) 200 d) 400 e) 600

The drain current of an enhancement N-channel MOSFET is measured at several values of $V_{GS}$, $V_{DS}$, and $V_{SB}$, as shown in the table below.
For this MOSFET, $\mu_n C_{ox} = 50\ \mu\text{A/V}^2$, $\gamma = 0.4\ \text{V}^{1/2}$, and $2\phi_f = 0.6\,\text{V}$.

| $V_{GS}$ (V) | $V_{DS}$ (V) | $V_{SB}$ (V) | $I_D$ ($\mu$A) |
|---|---|---|---|
| 2 | 5 | 0 | 158.4 |
| 3 | 5 | 0 | 532.4 |
| 3 | 6 | 0 | 542.08 |
| 3 | 5 | 3 | $I_X$ |
| 3 | 0.5 | 0 | $I_Y$ |

8. Find the value of $V_{t0}$ (in V).
a) 0.80 b) 0.60 c) 1.2 d) 1.4 e) 1.6

9. Find the output resistance $r_o$ in saturation (in kΩ) corresponding to $V_{GS} = 3\,\text{V}$ and $V_{SB} = 0$.
a) 85.03 b) 78.12 c) 123.46 d) 173.61 e) 103.31

10. Find the aspect ratio *W*/*L*.
a) 2 b) 5 c) 10 d) 12 e) 4

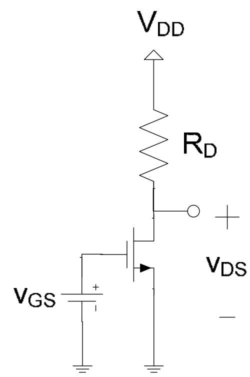
11. Find $I_X$ (in $\mu$A).
a) 364.2 b) 298.4 c) 250.9 d) 337.2 e) 209.3

12. Find $I_Y$ (in $\mu$A).
a) 345 b) 195 c) 107.5 d) 337.5 e) 193.7

13. An enhancement PMOS transistor has $k'_p(W/L) = 100\ \mu\text{A/V}^2$, $V_t = -1\,\text{V}$, and $\lambda = -0.02\ \text{V}^{-1}$. The gate is connected to ground, and the source to +3 V. Find the drain current (in $\mu$A) for $V_D = -3$ V.
a) 960 b) 1550 c) 2304 d) 224 e) 522

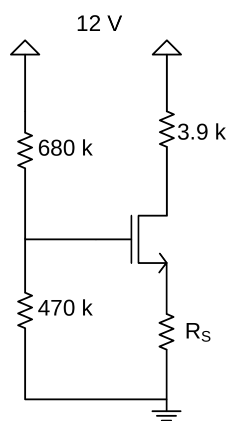
14. Find the value of the resistor $R_D$ (in kΩ) in the circuit shown below if the MOSFET is biased at a drain current of 1 mA.
The MOSFET parameters are $V_{t0} = 0.75$ V, $k'(W/L) = 0.2$ mA/V$^2$, and $V_A = 5$ V. Assume $V_{GS} = 3$ V and $V_{DD} = 7$ V.

a) 1.1 b) 2.1 c) 3.1 d) 4.1 e) 5.1




15. Find the voltage $V_{DS}$ (in V) for the MOSFET in the circuit shown below. The MOSFET parameters are $V_{t0} = 1$ V and $k'(W/L) = 0.5$ mA/V$^2$. Assume $R_S = 1000$ Ω.

a) 5.21 b) 4.26 c) 4.77 d) 3.23 e) 3.76




16. In the previous problem, what value of $R_S$ (in Ohms) places the MOSFET *at the edge* of the saturation region?

a) 422 b) 357 c) 281 d) 493 e) 196

Consider the MOSFET amplifier shown in Figure B. The MOSFET is biased in the saturation region such that $V_{OV} = V_{GS} - V_t = 1\,\text{V}$ and $I_D$ = 0.7 mA. The capacitors are very large and $R_A = R_B$ = 200 kΩ, $R_D$ = 15 kΩ, $R_L$ = 20 kΩ, $R_{sig}$ = 10 kΩ. Neglect channel-length modulation.

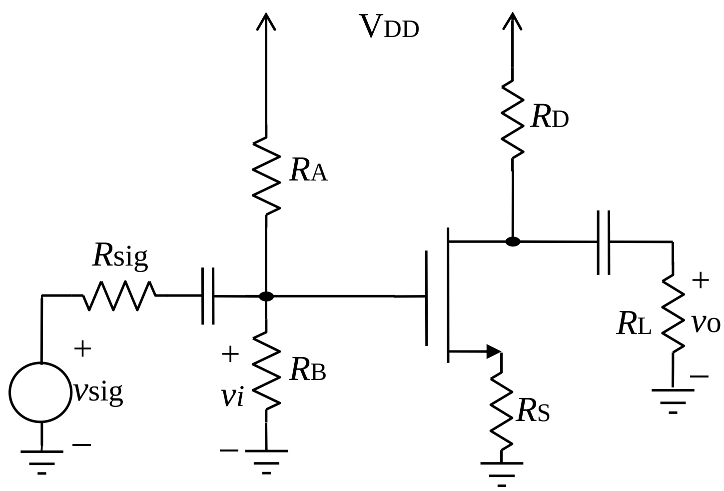
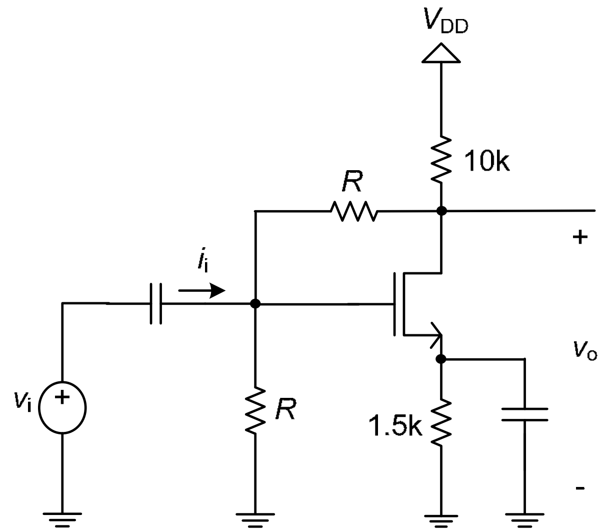



**Figure B**

17. Find $g_m$ (in mA/V).
a) 1.8 b) 1.6 c) 1.0 d) 1.2 e) 1.4

18. Assume $g_m$ for the MOSFET is 1.4 mA/V. Find the small-signal voltage gain $v_o/v_i$ (in V/V) if $R_S$ is replaced by a short circuit.
a) –15.4 b) –13.7 c) –12.0 d) –10.3 e) –8.6

In the circuit shown below, the MOSFET is biased in the saturation region such that $g_m$ = 1 mA/V and $r_o$ = 50 KΩ. Assume that all capacitors are very large, and that $R$ = 470 kΩ.




19. Find the small-signal voltage gain $v_o/v_i$.

a) –8.2 b) –9.0 c) –5.7 d) –6.5 e) –7.3

20. Find the input resistance $v_i/i_i$ in kΩ.

a) 61 b) 55 c) 50 d) 46 e) 43

21. Assume that the gain from gate to drain $v_o/v_i$ is *very large*. What is the maximum signal swing (in V) at the drain that keeps the MOSFET in saturation?
The transistor is biased at $V_{OV} = V_{GS} - V_t$ = 1 V, $V_{DS}$ = 3 V. $V_{DD}$ is very large.

a) +/– 3 b) +/– 4 c) +/– 3.5 d) +/– 2 e) +/– 2.5