American University of Beirut
Department of Electrical and Computer Engineering

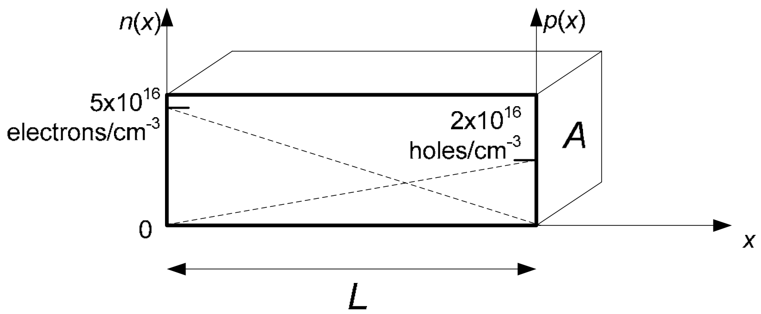
EECE 310 – Electronics
Quiz 2 – December 7, 2007
Closed Book – *No Programmable Calculators*
90 minutes
Penalty is 5 to 1

Name: ______________________________ ID number: _______________

Use
$n_i \approx 1.25\times10^{10}$ / cm^3
D_p = 12 cm^2/s, D_n= 34 cm^2/s
μ_p = 470 cm^2/V.s, μ_n = 1333 cm^2/V.s.
$q = 1.6\times10^{-19}$ C
$k = 1.38\times10^{-23}$ J/K
1 μm = 10^{-4} cm
$V_T \approx 25$ mV (when T is not specified)

Questions 1 to 4 are not included in Fall 2008-2009 Quiz 2

1. The electron and hole concentrations in a semiconductor material are as shown in the figure below.



The direction of current flow is in the:
a) negative x direction for holes, positive x direction for electrons
b) positive x direction for holes, positive x direction for electrons
c) negative x direction for holes, negative x direction for electrons
d) positive x direction for holes, negative x direction for electrons
e) none of the above

2. In Problem 1, the magnitude of the total current (in μA) when L = 2.5 μm and A = 1 μm^2 is:
a) 10.3 b) 31 c) 20.7 d) 15.5 e) 12.4

3. A PN junction diode is formed by doping the P type at a density $N_A = 4\times10^{16}$ cm^{-3} and the N type at a density $N_D = 5\times10^{17}$ cm^{-3}. Find the minority concentration in the N-type material (in cm^{-3}).

a) 390.6 b) 260.4 c) 520.8 d) 223.2 e) 312.5

4. Find the potential barrier (in V) at $T = 273$ K, when the doping density of acceptors is increased to 7×10^{16} cm^{-3}.

a) 0.758 b) 0.769 c) 0.778 d) 0.785 e) 0.792

5. An N-channel MOSFET with $k' = 100$ μA/V^2 is biased in the triode (linear) region. The drain current is 1 mA at an overdrive voltage of 0.6 V. When V_{OV} increases to 0.8 V, with constant V_{DS}, the drain current increases to 1.9 mA.
Find the value of V_{DS} (in V).

a) 0.89 b) 0.84 c) 0.63 d) 0.76 e) 0.4

6. Find the value of (W/L) for the MOSFET in the previous problem.

a) 72.8 b) 62.5 c) 55.7 d) 59.6 e) 65.8

7. A P-channel MOSFET is biased at $V_{GS} = -3$, $V_{DS} = -1$, and has a threshold voltage $V_t = -1$ V. Find its region of operation.

a) Saturation
b) Not enough data to decide
c) Triode (linear)
d) Cut-off
e) None of the above

8. In the circuit shown in Figure A, find the value of V_{DD} (in V) that will place the MOSFET at the *edge* of saturation (i.e. at the intersection between triode and saturation). Assume $R_D = 6$ KΩ, and for the MOSFET:
$k'(W/L) = 0.5$ mA/V^2 and $V_t = 0.7$ V.

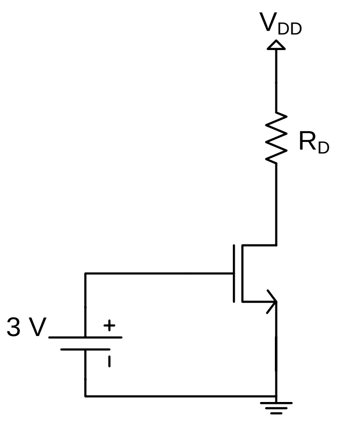


Figure A

a) 10.2 b) 11.6 c) 8.91 d) 6.27 e) 7.59

9. In the circuit shown in Figure A, assume V_{DD} = 12 and R_D = 5 KΩ. For the MOSFET: $k'(W/L)$ = 0.5 mA/V^2, V_t = 0.8 V, and λ = 0.03 V^{-1}.
Find the value of V_{DS} (in V) for the MOSFET.

a) 3.89 b) 2.81 c) 6.25 d) 5.04 e) 7.55

10. Find the value of g_m (in mA/V) for the MOSFET in Problem 9.

a) 1.67 b) 1.47 c) 0.81 d) 1.04 e) 1.26

11. Find the value of r_o (in KΩ) for the MOSFET in Problem 9.

a) 45.9 b) 34.4 c) 27.5 d) 22.9 e) 19.7

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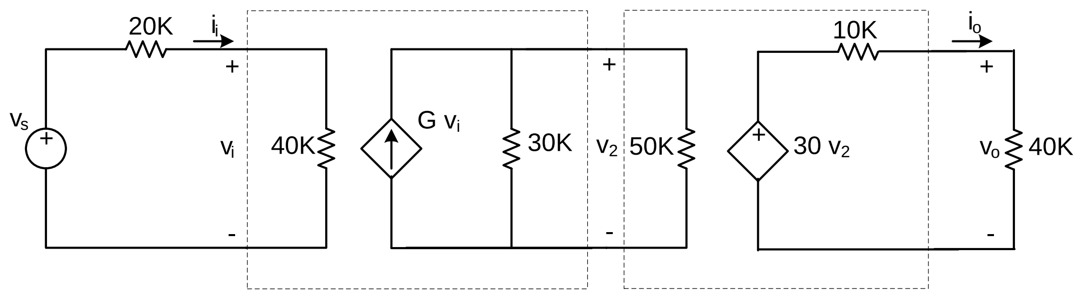
12. Consider the two-stage amplifier shown below. What should be the value of G (in mA/V) to get an overall voltage gain v_o/v_s of 750?



a) 2 b) 2.5 c) 3 d) 1 e) 1.5

13. Find the overall current gain, in the circuit of Problem 12, i_o/i_i, *when the 40K load is replaced by a short circuit*. Assume that G = 7 mA/V.

a) 20250 b) 15750 c) 11250 d) 13500 e) 18000

Consider the MOSFET amplifier shown in Figure B. The capacitors are very large.

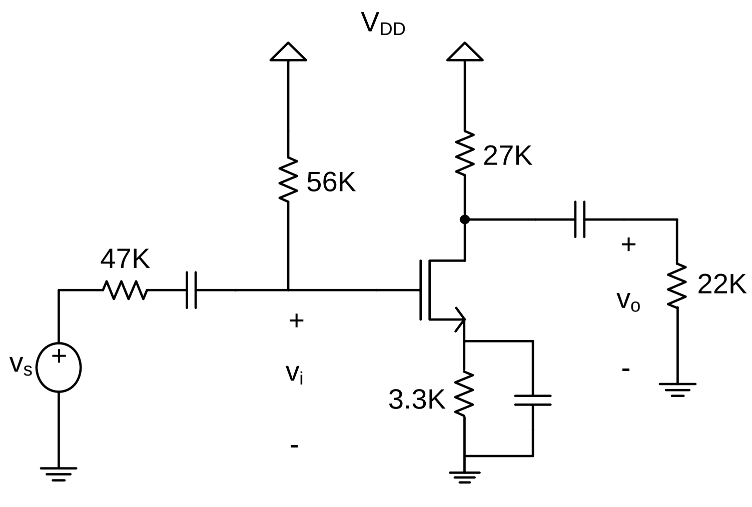


Figure B

14. The MOSFET is biased such that g_m = 0.85 mA/V and r_o = 100 KΩ. Find the small-signal voltage gain of the amplifier (v_o/v_i).

a) –9.7 b) –7.6 c) –8.1 d) –8.6 e) –9.2

15. Assume that the gain from gate to drain v_o/v_i is –10. What should be the DC voltage at the drain (in V) in order to have a signal swing of +/– 2 V at the drain, while keeping the MOSFET in saturation? The transistor is biased at V_{OV} = 0.7 V. Neglect signal distortion.

a) 3.1 b) 3.3 c) 2.7 d) 2.9 e) 2.5

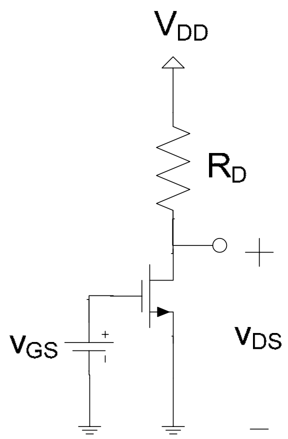
16. Find the input resistance (in KΩ) of the amplifier shown in Figure B.

a) 56 b) 68 c) 82 d) 39 e) 47

To analyze the circuit shown below, we use the MOSFET characteristics shown in Figure C. The $i_D - v_{DS}$ curves correspond to the following values of V_{GS}: 1.2, 1.7, 2.2, 2.7, and 3.2 V.

The three points shown on the plot have the following coordinates (3.3 V , 3.26 mA), (3.3 V , 5.10 mA), and (4.5 V , 5.36 mA)

Assume that V_{DD} is 5 V and R_D = 1 KΩ.



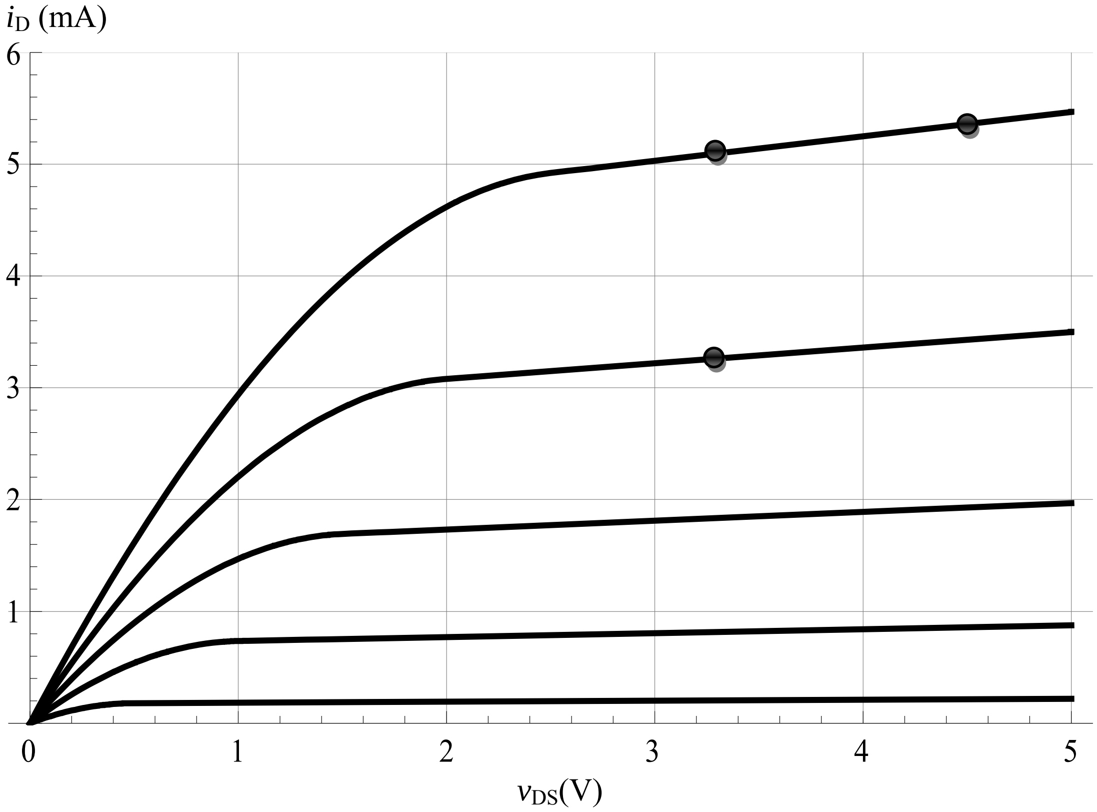


Figure C

17. Find the drain current (in mA) at the operating (Q) point of the MOSFET when $V_{GS} = 2.2$ V.
a) 1.8 b) 3.1 c) 3.6 d) 0.8 e) 0.3

18. Determine the value of λ (in V^{-1}) for the MOSFET.
a) 0.05 b) 0.07 c) 0.03 d) 0.02 e) 0.01

19. Determine the value of V_t (in V) for the MOSFET.
a) 1.3 b) 1.1 c) 0.7 d) 0.9 e) 0.5

20. What is the region of operation of the MOSFET if V_{GS} is raised to 3.2 V?
a) Linear b) Saturation c) Cut-off d) Not enough data to decide

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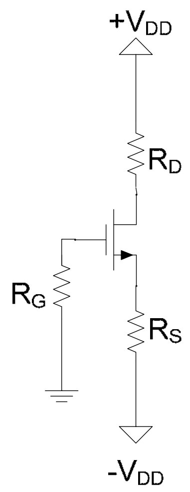
In the circuit shown below, V_{DD} is 9 V. The resistor values are $R_D = 3.3$ KΩ, $R_S = 2.2$ KΩ, and $R_G = 470$ KΩ.



21. Find the voltage at the gate of the MOSFET.
a) $V_{DD}/2$ b) 0 c) V_{DD} d) $-V_{DD}$ e) none of the above

22. Find V_{DS} (in V) if I_D = 1 mA.
a) 4.5 b) 6.5 c) 8.5 d) 10.5 e) 12.5

23. Find I_D (in mA) when the MOSFET parameters are $k'(W/L)$ = 1 mA/V^2 and V_t = 1.2 V.
a) 1.78 b) 2.52 c) 1.06 d) 1.42 e) 2.15

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24. The threshold voltage of an N-channel MOSFET increases from 0.8 to 1.1 V when the source-to-body voltage (V_{SB}) increases from 0 to 3 V. Find the value of γ (in V$^{1/2}$) for this transistor. Assume that $2\phi_f = 0.6$ V.
a) 0.445 b) 0.623 c) 0.356 d) 0.267 e) 0.534

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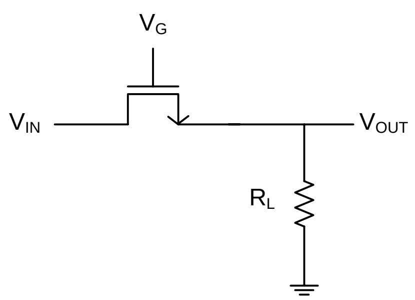
25. In the circuit shown below, V_{IN} is a *very small* voltage. Find the minimum V_G (in V) such that the circuit attenuates V_{IN} by not more than 5%. Assume R_L = 150 Ω. For the MOSFET: $k'(W/L)$ = 1 mA/V^2 and V_t = 0.8 V.



a) 1.22 b) 1.85 c) 1.15 d) 1.33 e) 1.50