American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 Electronics — Final Exam - Closed Book

2 hours (120 minutes) — December 18, 2015

ALL QUESTIONS ARE GRADED EQUALLY

PENALTY IS 5 TO 1

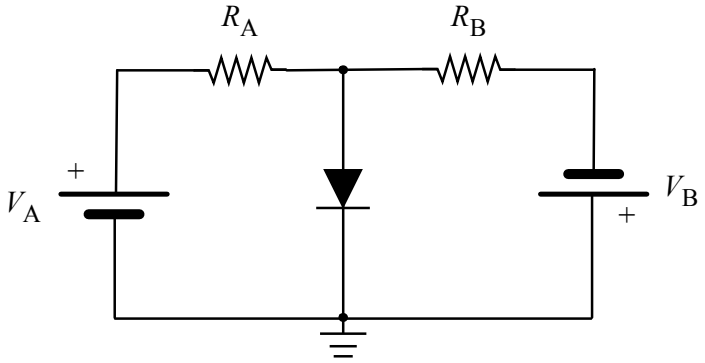
NAME _____ ID number _____ signature here _____

SIGN: ***I HAVE NEITHER GIVEN NOR RECEIVED AID ON THIS EXAM***

- There are 8 pages and 25 problems
- Unless otherwise specified, assume that:

- $V_T = 25$ mV
- $|V_{BE(ACTIVE)}| = 0.7$ V
- $|V_{BE(SAT)}| = 0.7$ V
- $|V_{CE(SAT)}| = 0.2$ V
- $|V_{CE(EDGE\ OF\ SAT)}| = 0.3$ V
- All capacitors are very large
- *Base-width modulation (Early effect) and channel-length modulation effects are negligible*

1. In the circuit shown below, the diode is ideal. At what value of V_A (in V) does the diode start to conduct? Assume that $R_A = 22$ kΩ, $V_B = 16$ V, and $R_B = 10$ kΩ.



a) 35.2 b) 30.8 c) 26.4 d) 39.6 e) 44.0

2. Find the current in R_A (in mA) when $V_A = 10$ V.
a) 0.750 b) 0.813 c) 0.875 d) 0.938 e) 0.688

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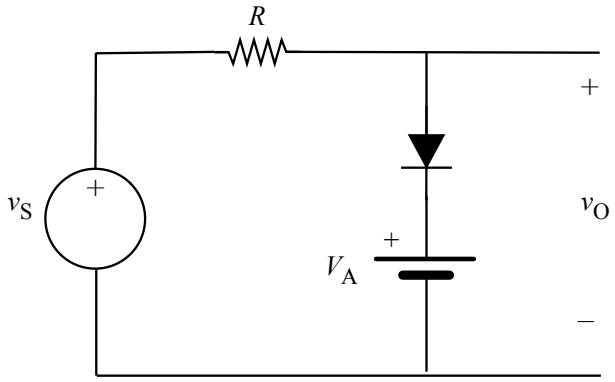
3. In the circuit shown below, the diode drops 0.7 V when conducting, and is considered an open-circuit when OFF. Find the maximum diode current (in mA) if v_S is a square wave that varies between +20 V (for 50% of the time) and –20 V (for the other 50% of the time). Assume $V_A = 8$ V and $R = 2.2$ kΩ.



a) 2.86 b) 5.14 c) 4.23 d) 3.77 e) 3.32

4. In the previous problem, find the average value of the output voltage v_O (in V).
a) –3.65 b) –3.15 c) –5.65 d) –4.65 e) –4.15

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5. A series connection of 10 identical PN junction diodes in the same polarity, also connected in series with a battery such that all diodes are forward biased, results in a forward current of 1 mA when the battery voltage is 7 V, and 6 mA when the battery voltage is 7.5 V. Find the value of n for the diodes.
a) 1.820 b) 1.116 c) 1.243 d) 1.443 e) 1.028

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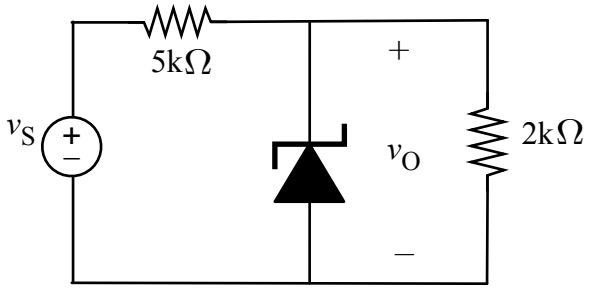
6. Consider the Zener diode in the circuit shown below. The diode has V_{Z0} = 12.0 V, r_Z = 100 Ω, and I_{ZK} = 5 mA. Find the output voltage v_O (in V) when v_S is 35.0 V?



a) 10.0 b) 11.0 c) 11.5 d) 11.7 e) 11.9

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7. A logic inverter has $NM_L = NM_H$ = 0.5 V, V_{OL} = 0.4 V, and V_{OH} = 3.5 V. Find the value of V_{IL} for this inverter (in V).

a) 0.9 b) 1.0 c) 0.7 d) 0.8 e) 0.6

The drain current of an enhancement NMOS is measured at several values of V_{GS} and V_{DS}, as shown in the table below. For this MOSFET: $k_n' \frac{W}{L} = 1$ mA/V^2, $V_t = 1$ V, and $\lambda \neq 0$. Answer the following 2 questions.

V_{GS} [V]	V_{DS} [V]	I_D [mA]
3	3	2.06
3	8	I_{D1}
3	0.2	I_{D2}

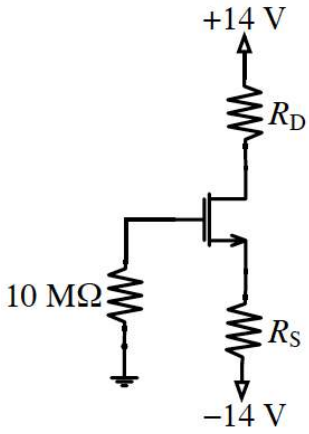
8. Find the value of I_{D1} (in mA).

a) 2.48 b) 2.16 c) 2.24 d) 2.32 e) 2.40

9. Find the value of I_{D2} (in mA).

a) 0.38 b) 0.72 c) 1.02 d) 1.28 e) 1.5

The enhancement NMOS in the circuit shown below has $k_n'\frac{W}{L} = 2$ mA/V^2, $V_t = 1$ V, and $\lambda = 0$. R_D = 6 kΩ and the MOSFET operates at the *boundary* between the triode and saturation regions. Answer the following 2 questions.



10. Find the value of the drain current I_D (in mA).

a) 2.5 b) 7.5 c) 5 d) 3.75 e) 3

11. Find the value of R_S (in kΩ).

a) 3.76 b) 4.57 c) 1.37 d) 2.15 e) 2.95

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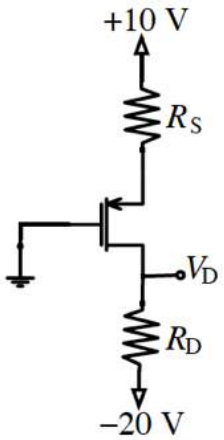
12. The enhancement PMOS in the circuit shown has $k_p'\frac{W}{L} = 2$ mA/V^2, $V_t = -1.5$ V, and $\lambda = 0$. Find V_{DS} (in V) if $R_D = R_S$, and the MOSFET is biased such that $V_{GS} = -3.5$ V.

a) –15 b) –16 c) –17 d) –19 e) –18



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13. A voltage amplifier has an *open-circuit* voltage gain of 100 V/V, an output resistance of 100 Ω, and a power gain of 150×10^6 W/W when a 100 Ω load is connected across the output terminals. Find the input resistance (in MΩ).

a) 6 b) 5 c) 2 d) 3 e) 4

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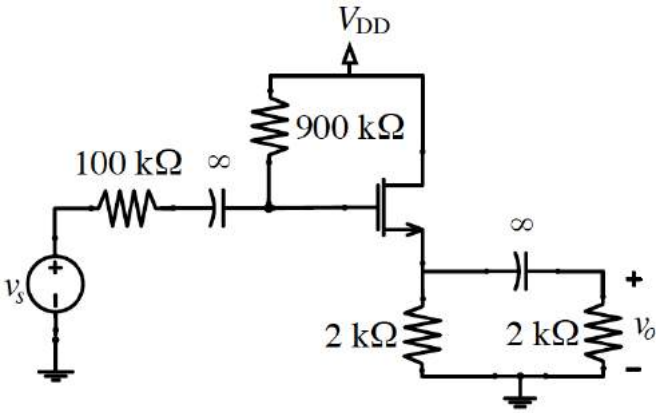
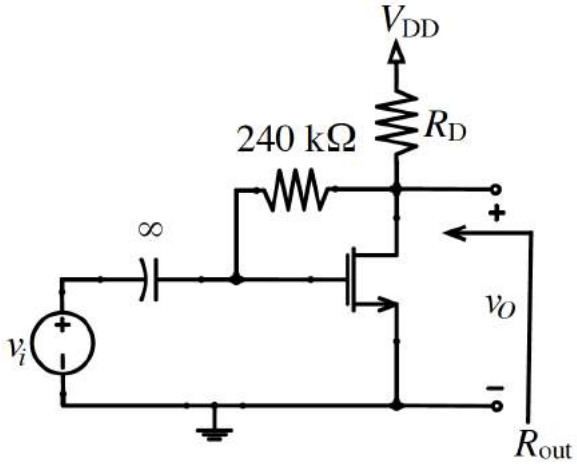
14. The enhancement NMOS in the circuit shown below is biased in the saturation region such that the gate to source overdrive voltage V_{OV} is 0.5 V and the drain current I_D = 1 mA. If v_s is a 60 mV peak-to-peak sinusoid, find the peak-to-peak variation of v_o (in mV). Assume that $\lambda = 0$.

a) 36.0 b) 43.2 c) 50.4 d) 21.6 e) 28.8



The enhancement NMOS in the circuit shown below has an early voltage V_A = 75 V; it is biased in the saturation region such that I_D = 1 mA and V_{DS} = 5 V. v_i is a signal voltage. Answer the following 2 questions.



15. If R_{out} = 10 kΩ, find the value of R_D (in kΩ).

a) 25.71 b) 9.23 c) 12 d) 18.26 e) 21.82

16. If R_D = 20 kΩ and the MOSFET transconductance g_m = 1.2 mA/V, find the small-signal voltage gain v_o/v_i (in V/V); v_o is the signal component of the total output voltage v_O.

a) –23.94 b) –17.94 c) –20.94 d) –26.94 e) –14.94

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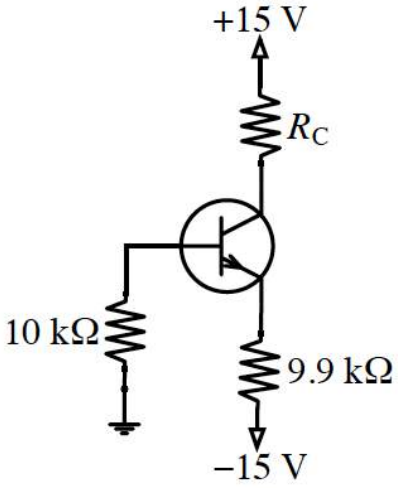
17. The *npn* transistor in the circuit shown below has $\beta = 99$. Find the value of V_{CE} (in V) if $R_C = 6$ kΩ.

a) 10.18 b) 8.76 c) 7.35 d) 5.93 e) 4.52



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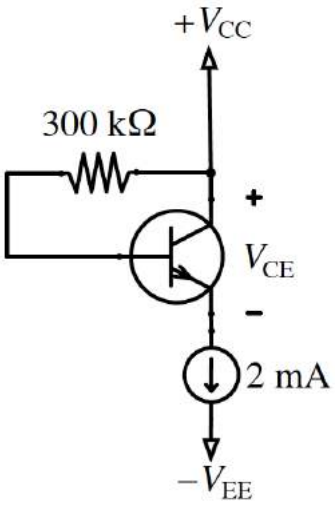
18. The *npn* transistor in the circuit shown below is biased such that $V_{CE} = 4.7$ V. Find the value of β.

a) 74 b) 59 c) 119 d) 99 e) 149



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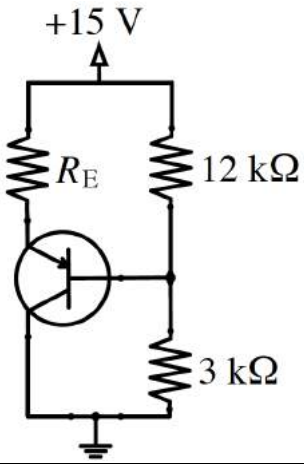
19. The *pnp* transistor in the circuit shown below has $\beta = 49$. Find the value of I_E (in mA) if $R_E = 3$ kΩ.

a) 1.12 b) 10.78 c) 5.52 d) 3.71 e) 2.79



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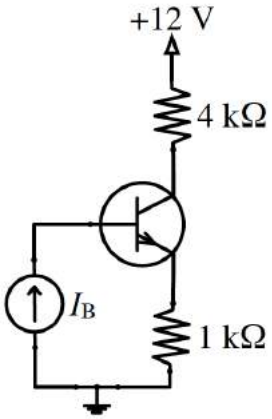
20. The *npn* transistor in the circuit shown below has $\beta = 119$. Find the value of I_B (in μA) so that the transistor operates at the *Edge of Saturation*.

a) 29.55 b) 19.63 c) 59.69 d) 47.56 e) 39.53



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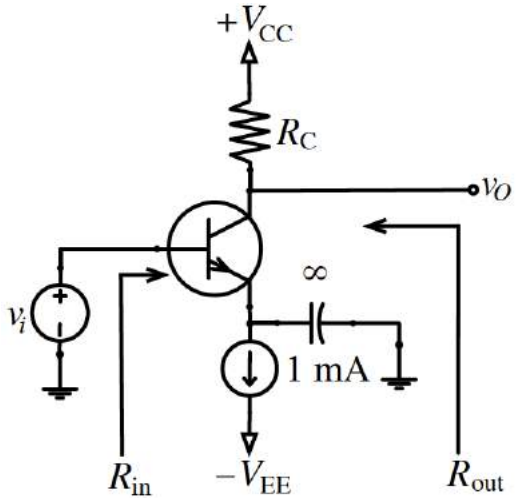
21. An *npn* transistor has $\beta = 49$; it is biased in the active mode so that its small-signal T-model has $r_e = 10$ Ω. Find the value of the DC current in the collector (in mA).

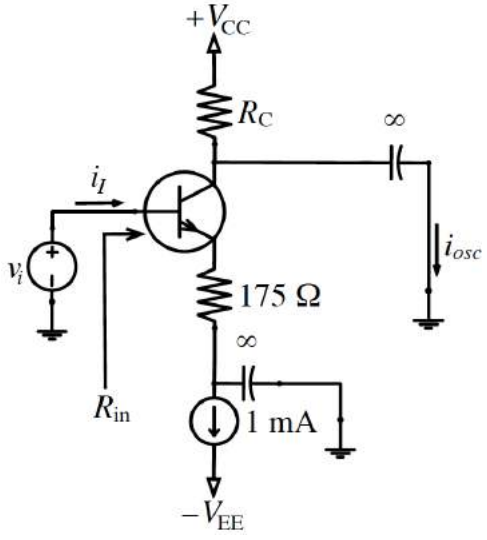
a) 6.13 b) 2.45 c) 3.06 d) 4.90 e) 1.63

The *npn* transistor in the circuit shown below is biased in the active region; v_i is a pure signal voltage with zero DC component. The small-signal voltage gain $v_o/v_i = -43.56$ V/V, where v_o is the signal component of the total output voltage v_O. Answer the following 2 questions.



22. Find the value of β if $R_{in} = 1.25$ kΩ.
a) 69 b) 79 c) 89 d) 49 e) 59
23. Find the value of R_{out} (in kΩ) if $\beta = 99$.
a) 1.1 b) 1.2 c) 1.3 d) 1.4 e) 1.5

The *npn* transistor in the circuit shown below is biased in the active region; v_i is a pure signal voltage with zero DC component. The input resistance of the amplifier $R_{in} = 16.2$ kΩ. Answer the following 2 questions.



24. Find the small-signal short-circuit current gain i_{osc}/i_i (in A/A), where i_i is the signal component of the total input current i_I.
a) –140 b) –80 c) –100 d) –120 e) –60
25. Find the peak value of v_i (in mV) that results in a signal voltage v_{be} having a peak value of 1 mV.
a) 20 b) 8 c) 12 d) 16 e) 24