Physics 334, Winter Quarter 2012, Examination #2

Name SOLUTIONS V1.0

1	/25
2	/25
3	/25
4	/25
TOTAL	/100

Exam notes: Don't turn over the exam until the starting-buzzer and stop writing at the closing-buzzer. The exam is closed-book. You may use a calculator, but not smart phones, iPads or laptops. You may not use your own equation sheet. Please check that you have a total of 5 pages, including this page. You can make reasonable assumptions based on standard component tolerances of 5%, which may save you some time and effort. You may write in the margins, on scratch paper or on the back page of the exam, but that won't be graded. Sloppy or disorganized work may be downgraded.

Possibly useful equations and information:

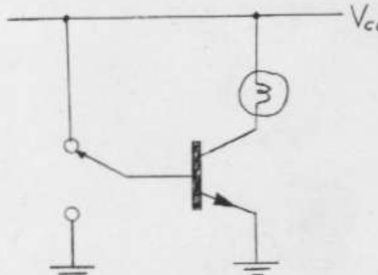
Ideal op-amp golden rules: (1) inputs source or sink no current; (2) the open-loop output voltage is ($V^+ - V^-$) times an arbitrarily large gain; (3) if properly negatively fed-back, the inputs (V^+ and V^-) are at the same voltage.

The tranconductance of a FET is the change in the drain current divided by a change in the gate-to-source voltage.

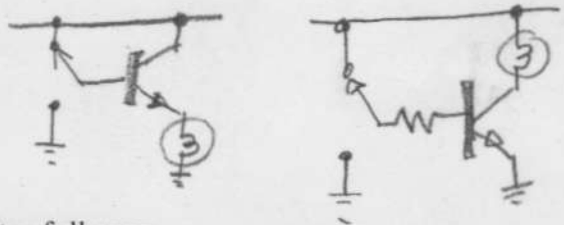
The "3 dB" frequency of a RC high- or low-pass filter is $1/(2\pi RC)$

1. (25 points total) "Bad circuits." Each circuit below has a glaring fault that makes it bad. To the immediate right of each circuit, (i) explain in 10 words or less why the circuit is bad and, (ii) after correcting the fault, sketch a corrected "good" circuit.

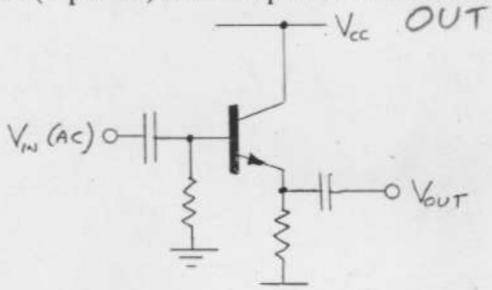
a. (6 points) Transistor switching a light-bulb



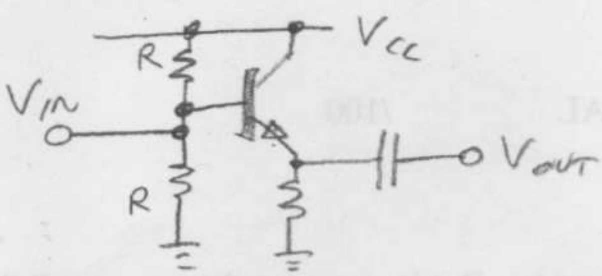
HUGE CURRENT INTO BASE DESTROYS TRANSISTOR. POSSIBLE FIXES:



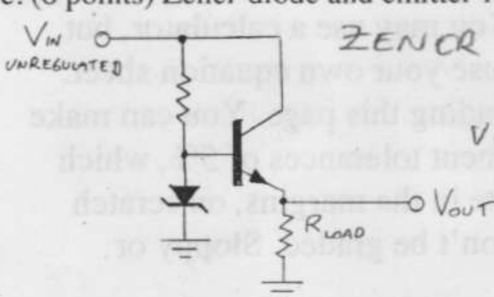
b. (6 points) AC-coupled emitter-follower



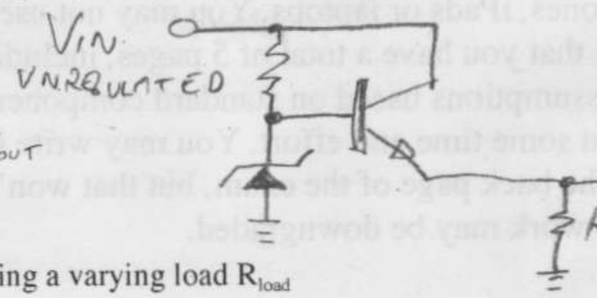
OUTPUT CLIPPING. POSSIBLE FIX!



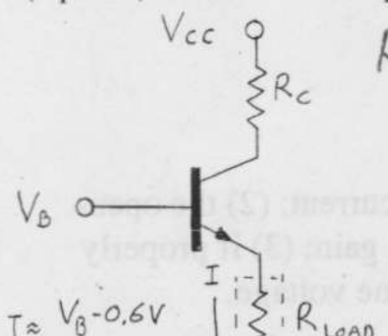
c. (6 points) Zener-diode and emitter-follower voltage regulator



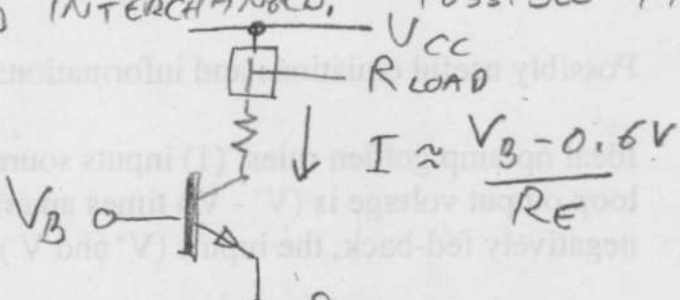
ZENER BACKWARDS. POSSIBLE FIX!



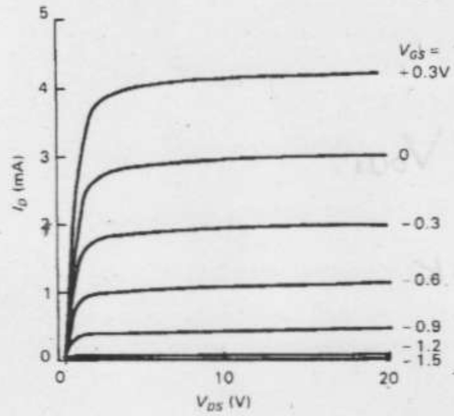
d. (7 points) Current source supplying a varying load R_{load}

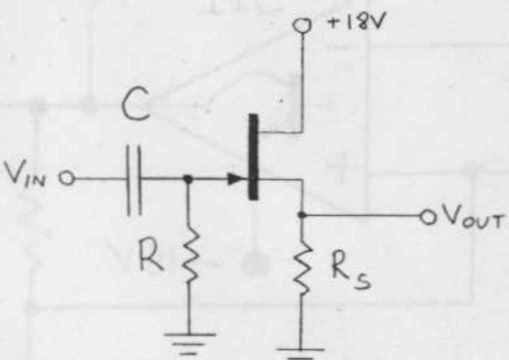


R_C & R_{LOAD} INTERCHANGED. POSSIBLE FIX



2. (25 points total) Consider an AC-input-coupled source-follower, shown below, made from a n-channel JFET. Its drain current I_D versus V_{DS} curves for various values of gate-to-source voltage V_{GS} are also shown below.





a. (6 points) Suppose you'd like the quiescent (no-signal) current to be approximately 1 mA; what's an appropriate value of R_s? LOOKING AT CURVES OF I_D VS V_{DS}, FOR $I_D = 1$ mA, $V_{GS} = -0.6$ V.

HENCE $R_S = 0.6\text{V}/1\text{mA} = 600\ \Omega$

b. (6 points) With respect to the quiescent current I_D, should the value of the R be (circle one) (i) much larger than R_s; (ii) much smaller than R_s; (iii) about equal to R_s; or (iv) the value of R relative to R_s doesn't much matter. SINCE NO CURRENT FLOWS INTO THE GATE, $V_G \cong 0$.

c. (7 points) Further suppose you'd like the follower to pass 100 Hz signals with only 3 dB attenuation. Find appropriate values for R and C. (This following is a detail, so don't let it trip you up, but you can assume the transconductance g_m is very large compared to $1/R_s$ for all I_D.)

$\omega_{3dB} = \frac{1}{RC} \Rightarrow f_{3dB} = \frac{1}{2\pi RC}$

FOR R, FOR EXAMPLE, $= 1\ \text{k}\Omega$, $C \approx 1.6\ \mu\text{F}$.

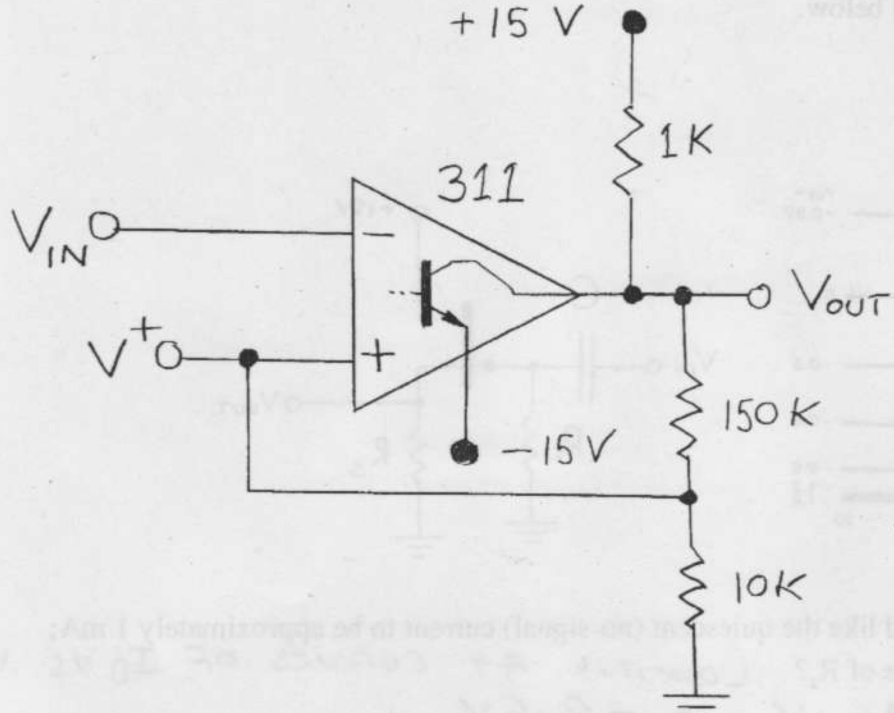
d. (6 points) How much amplitude can the input signal have before the output becomes seriously clipped, exhibits other pathological behavior or otherwise is no longer a good follower? Explain your answer in 10 words or less.

WHEN $V_{GS} \lesssim -1.2\text{V}$, $I_D \to 0$ (TRANSISTOR SHUTS OFF).

HENCE $|(-1.2\text{V}) - (-0.6\text{V})| \cong 0.6\text{V}$.

NOTE: 0.6V IS SMALLER THAN THE VOLTAGE THAT CAUSES GATE CONDUCTION: $0.7\text{V} - (V_{GS} \approx -0.6\text{V}) \approx 1.3\text{ V}$.

3. (25 points total) Consider the 311 comparator circuit below. (Recall the 311 has both open-collector and uncommitted-emitter outputs.) V^+ is a test-point where you'll measure a voltage.



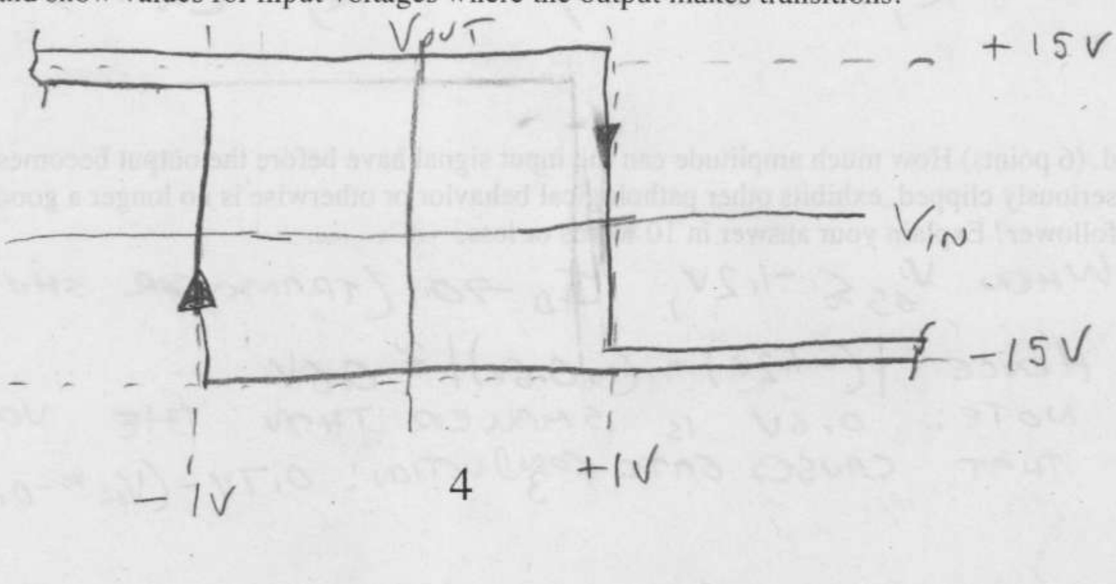
a. (8 points) When Vin = +15 V, what's Vout and V^+?

Vout = −15.V V^+ = ≈ −1. V.

b. (8 points) When Vin = -15 V, what's Vout and V^+?

Vout = +15. V V^+ = ≈ +1. V.

c. (9 points) Consider an input-voltage excursion of Vin from -15 V to +15 V then back to -15 V. Draw below the hysteresis curve for this excursion. That is, make a neat and careful plot of Vin on the horizontal axis and Vout on the vertical axis for the excursion. Where the plot exhibits hysteresis, indicate the direction of the excursion with arrows. Ensure you indicate and show values for input voltages where the output makes transitions.



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4. (25 points total)
Shown below are six op-amp circuits with input voltage of either +1 V or –1 V as shown. On each circuit drawing, write at V_{out} the output voltage for each circuit. Assume the op-amps are ideal and the output level can swing anywhere between the +15 V and –15 V op-amp power supply voltages. You may also assume ideal diodes with forward voltage drop 0.7 V.