Test 1

EE315 Fall 2017—Dr. B

NAME SOLUTION KEY

DO ALL YOUR WORK ON THIS EXAM. USE THE BACK SIDES of EXAM PAPER IF NECESSARY BUT POINT ME WHERE YOU DID THAT.

- ***Your Equation sheet must be turned in with the Exam.***
- ***NO Cell PHONE Calculators allowed. Other calculators ok.***
- ***Closed books/closed lecture notes.***
- ***Each Problem worth ~~16~~ 15 points.***

(1) Dr. B's 4th law of Thermodynamics- "If the heat is on somebody else it is not on you!" Keep that in mind for your future engineering career.

(2) "Your odds are good finding an engineering student to date but the goods are odd". (heard this from an engineering student last term).

Problem 1: Circle either true or false (~~2~~ 1 point~~s~~ each):

(log base 10)

1. (True False) Amplifier power gain is 10 log to base e of (Vout/Vin).

2. (True False) Amplifier "efficiency" is defined as how accurately the output signal "follows" the input signal. $\eta \approx \frac{P_L}{P_{delivered}}$

3. (True False) The ideal operational amplifier has the following characteristics: ~~infinite~~ zero output resistance, ~~zero~~ infinite input resistance, ~~finite~~ infinite gain, and infinite bandwidth.

4. (True False) The operational amplifier "rail voltages" provide DC power to the amplifier and set the saturation limits for the amplitudes of the amplifier's output voltage.

5. (True False) An ideal operational amplifier, by virtue of its design, inherently provides a high degree of common mode (i.e. noise) rejection.

6. (True False) A good example of a common mode signal is noise.

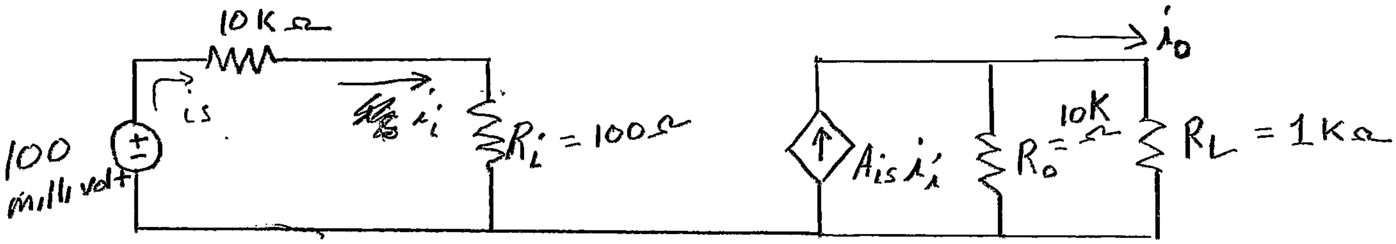
7. (True False) There are two types of input terminals for the operational amplifier; the inverting and the ~~difference~~ non-inverting input.

8. (True False) Voltage gain in decibels is 20 log (Vout/Vin).

9. (True False) A trans-resistance amplifier and a trans-conductance amplifier are two separate type families of amplifiers.

10. (True False) Feedback is applied to an operational amplifier in order to control the amount of gain the amplifier will provide.

PROBLEM 1: PC -Consider the current amplifier below. Find the current gain, io/is, and express your answer in decibels.



$$A_{is} = 100 \ \frac{\text{Amp}}{\text{Amp}}$$

Solution

by Current Div: $i_o = \left(\frac{R_o}{R_o + R_L}\right)\left(A_{is} i_i\right)$

$$= \left(\frac{10K}{11K}\right) 100\, i_i$$

$$i_o = 90.9\, i_i =$$

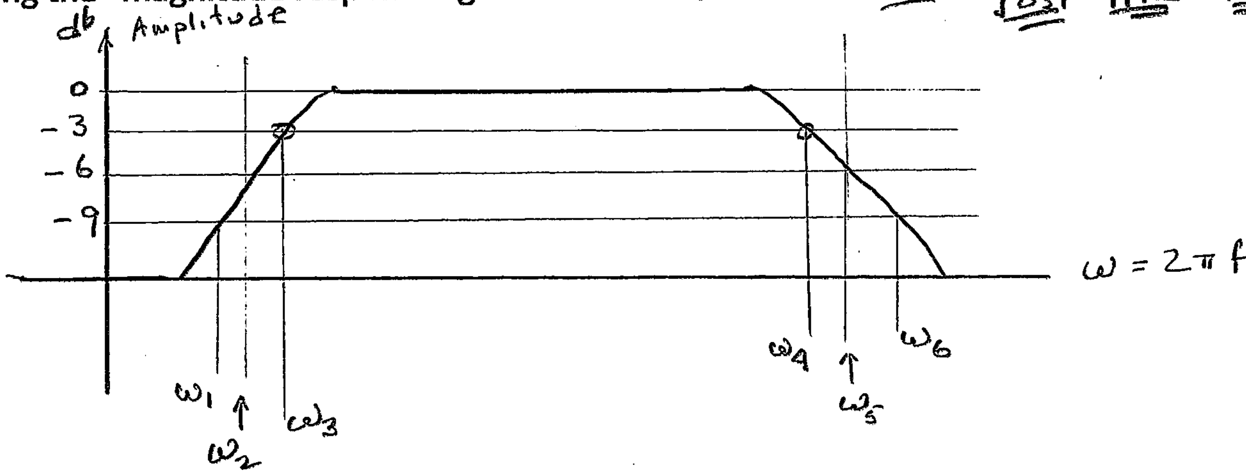
but $i_s = i_i$ ✓

$$i_o = 90.9\, i_s$$

$$\frac{i_o}{i_s} = 90.9 = \text{in db} \Rightarrow$$

$$20 \log 90.9 \Rightarrow \boxed{39.17 \text{db}}$$

Problem 2: NO PC- In the figure below, what is the "bandwidth" for the amplifier having the "magnitude response" given below? NOTE: This is semi-log plot just like text!



Select Correct Answer:

(a) $\omega_6 - \omega_1$

(b) $\omega_5 - \omega_2$

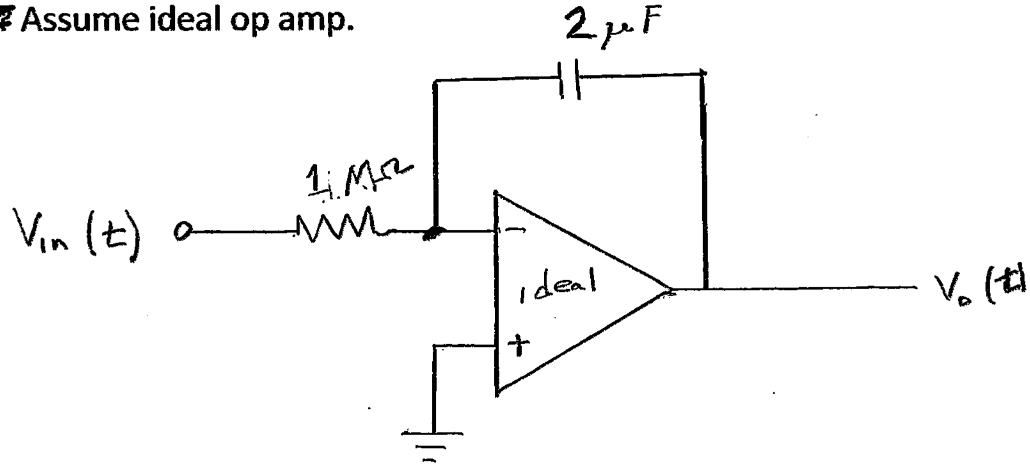
(c) $\omega_4 - \omega_3$

3 db down points along ω axis

A GIFT!

If you attended class! OR watched PAnopto Lectures

Problem 3: (PC) Given the op amp circuitry below, what is Vo(t) if Vin(t) = 10 sin t .
[redacted] Assume ideal op amp.



$$\frac{v_o}{v_{in}} = -\frac{1}{RC}\int v_{in}\,dt = -\frac{1}{(1\times10^{6})(2\times10^{-6})}\int_0^t 10\sin t\,dt$$

$$= -\frac{10}{2}\int_0^t \sin t\,dt = -5\left[-\cos t\Big|_0^t\right]$$

$$= 5\left[\cos t - 1\right]$$

$$\boxed{\frac{v_o}{v_{in}} = 5\cos t - 5}$$

v

Problem 4: (NO PC) Given an amplifier with current gain = 120 db and voltage gain = 50 db, what is the power gain, in db?

Given: $A_i = 120$ db $\quad A_v = 50$ db

$A_p = A_i A_v$

Recall the Algebra II formula $\log x = n$ means $10^n = x$

So Voltage gain in db $= 20 \log A_v$
current gain in db $= 20 \log A_i$
power gain in db $= 10 \log A_p$

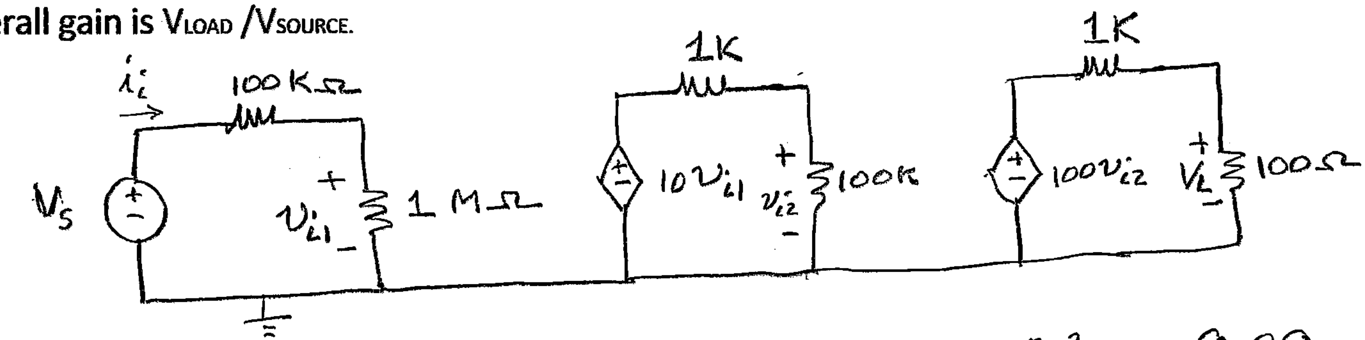
So $50 = 20 \log A_v \Rightarrow 2.5 = \log A_v$
$120 = 20 \log A_i \Rightarrow 6 = \log A_i$

$10^{2.5} = A_v = 316.22$
$10^{6} = A_i = 1{,}000{,}000$

$A_p = (316.22)(1{,}000{,}000) = 3.1622 \times 10^{8}$

$10 \log A_p = 10(8.499) = \boxed{84.99 \text{ db}}$

Problem 5: (PC) What is the overall gain of the cascaded amplifier shown below? Overall gain is V_{LOAD}/V_{SOURCE}.



$$v_L = \left(\frac{100}{1000+100}\right) 100\, v_{i2} = \frac{10000}{1100} v_{i2} = 9.09$$

$$\frac{v_L}{v_{i2}} = 9.09 \checkmark$$

$$v_{i2} = \left(\frac{1K}{1K+100K}\right) 10\, v_{i1} = \frac{10K}{101K} (10) v_{i1}$$

$$\frac{v_{i2}}{v_{i1}} = 9.9$$

$$v_{i1} = \left(\frac{1M}{1.1M}\right) V_s = .909$$

$$\frac{v_{i1}}{V_s} = .909$$

$$\frac{v_L}{v_s} = \frac{v_L}{v_{i2}} \times \frac{v_{i2}}{v_{i1}} \times \frac{v_{i1}}{v_s} = (9.09)(9.9)(.909)$$

$$\boxed{\frac{v_L}{V_s} = 81.8 \quad V/V}$$

Problem 6: (PC) I have an amplifier that I have determined by measurements that power delivered by the dc sources = 200 milliwatts , power dissipated within the amplifier itself is 125 milliwatts, and <u>power from the signal source itself is negligible.</u>

(a) What is the power delivered to the load such that the power equation is "balanced"?
<u>(note:</u> *I would expect the MAE's to do well here because its basic thermodynamics)*

(b) Compute the amplifier efficiency, and express your answer in per cent.

(a) $P_{SOURCES} = P_{DISS} + P_{LOAD}$

$$200 \text{ mW} = 125 \text{ mW} + P_{LOAD}$$

$$\boxed{P_{LOAD} = 75 \text{ mwatts}}$$

(b) $\eta = \dfrac{P_{LOAD}}{P_{SOURCES}} \cdot \dfrac{75}{200} = \boxed{37.5\%}$