

Name _____

You must show all work. If you don't show your work, you may not get credit even if the answer is correct, and you will not get partial credit. You must show enough that I can see the method you used.

1. (10 points) Short answer questions:

- a. What is the difference between a "depletion" device and an "enhancement" device, in their electrical measurements?

- b. What is the difference between a "depletion" device and an "enhancement" device, in processing?

- c. An N-channel device with $V_{th} = 0$ has the following measurements in a circuit: $V_{gs} = 2$, $V_{ds} = 10$, $I_d = 1$ ma. What region is it operating in?

- d. An N-channel device with $V_{th} = 0$ has the following measurements in a circuit: $V_{gs} = 2$, $V_{ds} = 0.01$, $I_d = 1$ ua. What region is it operating in?

(90 points) Design an IC amplifier is required with the following specs:

- Gain = 20 dB, non-inverting.
- Output impedance ≤ 50 ohms.
- Power supply = + and - 10 volts. (20 volts total)
- Output voltage swing > 4 volts p-p.
- Frequency response, +0, -3 dB, 100 Hz - 5000 Hz.
- Frequency response must be at least 3 dB below the midband level at 10000 Hz.

You are designing an IC. The process provides 4 kinds of MOSFETs:

1. N-channel, $K_P = 20\mu$, $V_t = 2$, $L_{min} = 10\mu$
2. N-channel, $K_P = 20\mu$, $V_t = -2$, $L_{min} = 10\mu$
3. P-channel, $K_P = 5\mu$, $V_t = -2$, $L_{min} = 10\mu$
4. P-channel, $K_P = 5\mu$, $V_t = 2$, $L_{min} = 10\mu$

- All devices have $\lambda = 0$.
- Since this is an IC amplifier, you are not restricted to standard values.
- You may set the size of the transistors to anything you need but you should keep area to a minimum.
- Both N and P channel are available, but the P-channel has lower transconductance so is less desirable, unless it helps you eliminate other components.
- Both "enhancement" and "depletion" devices are available, for your convenience in biasing. Use whichever gives you better biasing.
- Note that you have a balanced power supply. You should design it so you don't need coupling capacitors on either input or output. That is, the input gate voltage should be zero, and the output DC voltage should also be zero.
- There is a 10 point bonus if you can do the whole design without any capacitors.
- To get you started, pick the resistor in the output stage to be 2k, and drain resistors in voltage gain stages to be 1 meg.
- If you can't meet all the specs, state which ones you can't meet. Don't let it stop you from the rest of the problem.