1. Understand the basic operation of a MosFet:
   - 3 regions of operation: cutoff, triode, saturation and know all current equations associated with them.
   - the $I_D$ versus $V_{DS}$ graph
2. Understand the bias point concept for linear amplification.
3. Be able to separate the DC and AC analysis for a circuit containing MosFets.
4. Be able to analyze a circuit (with or without cap in it) containing MosFets for DC operation.
5. Be able to draw a small-signal model of MosFets in a circuit.
6. Be able to analyze a small-signal circuit to find overall gain, midband gain, input resistance, and output resistance.
7. Determine $\omega_L$ and $\omega_H$ or $f_L$ and $f_H$.

**Example 1**

Use: $V_t=2V$
   
   $k_n'(W/L)=6mA/V^2$
   
   $\lambda=0$

   $V_{sig}=3+0.002\sin(20t)$

For DC analysis, assume that the capacitors act as an open. The current source is not ideal and has a voltage drop across it.

(a) Solve for the DC currents:
   
   a. $I_{D1}=I_{S1}=3mA$
   
   b. $I_{S2}=I_{D2}=2mA$

(b) Solve for the DC voltages:
   
   a. $V_{G2}=2V$
   
   b. $V_{S2}=-0.82V$

   c. $V_{S1}=-3V$

(c) Verify that transistor M2 is saturated.

(d) State the DC bias point for transistor M1.

(e) Assuming that the transistor amplification is $V_o/V_{sig}=3V/V$. Assume the input frequency is operating within the circuits operating range. What is the total (AC and DC) instantaneous output for $V_o$ using the $V_{sig}$ value stated above.
   
   $V_{o_{total}}=6+6m\sin(20t)$
Example 2

Use: \( V_t = 2V \)

\( k_n'(W/L) = 10\text{mA/V}^2 \)

\( V_{\text{sig}} \) is an AC source

Transistor 1 has DC values: \( V_{GS} = 3V \)

Transistor 2 has DC values: \( V_{GS} = 12V \)

\( \lambda = 0 \) (for all transistors) and assume all transistors are saturated

For the following hybrid-\( \pi \) equivalent circuit, find the following values:

(a) \( R_{in} \) (input resistance –ignore the input source, \( V_{\text{sig}} \))

(b) \( R_{out} \) (output resistance-ignore \( R_L \) [no load is connected])

(c) ideal midband gain, \( \frac{V_o}{V_{\text{sig}}} \)

\( R_{in} = 98\text{ohms}, \quad R_{out} = 10k, \quad \frac{V_o}{V_{\text{sig}}} = 10V/V \)
Example 3

For the circuit shown below, draw the AC small-signal equivalent circuit (use hybrid-$\pi$ or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. $g_{m1}$, $v_{gs2}$, $r_{o1}$, etc.). $\lambda \neq 0$ for all transistors. (i.e. draw the small-signal with $r_o$ included). $v_{sig}=0.005\sin(20t)$ AC. Draw the small-signal equivalent circuit WITH capacitors shown.

Example 4

Use: $g_m=2.2\text{mA/V}$, $\lambda=0$, and $C_{gs}=C_{gd}=5\text{pF}$.

What is the operating range for the amplifier below (in Hz)?

478Hz to 5.3MHz
**Example 5**

\[ V_i = 2V, \lambda = 0, k_n'(W/L) = 2mA/V^2 \]  Does this circuit operate as a **linear** AC amplifier? If so, what is the gain, \( \frac{V_o}{V_{sig}} \), of the following circuit? If not, explain why.

\[ V_{sig} = 2.5 + \sin(\omega t) \] (assume that \( \omega \) is in the operating range of the circuit). If not, explain why.

No, does not amplify.