ECE 65: Components & Circuits Lab

Amplifier practice problems

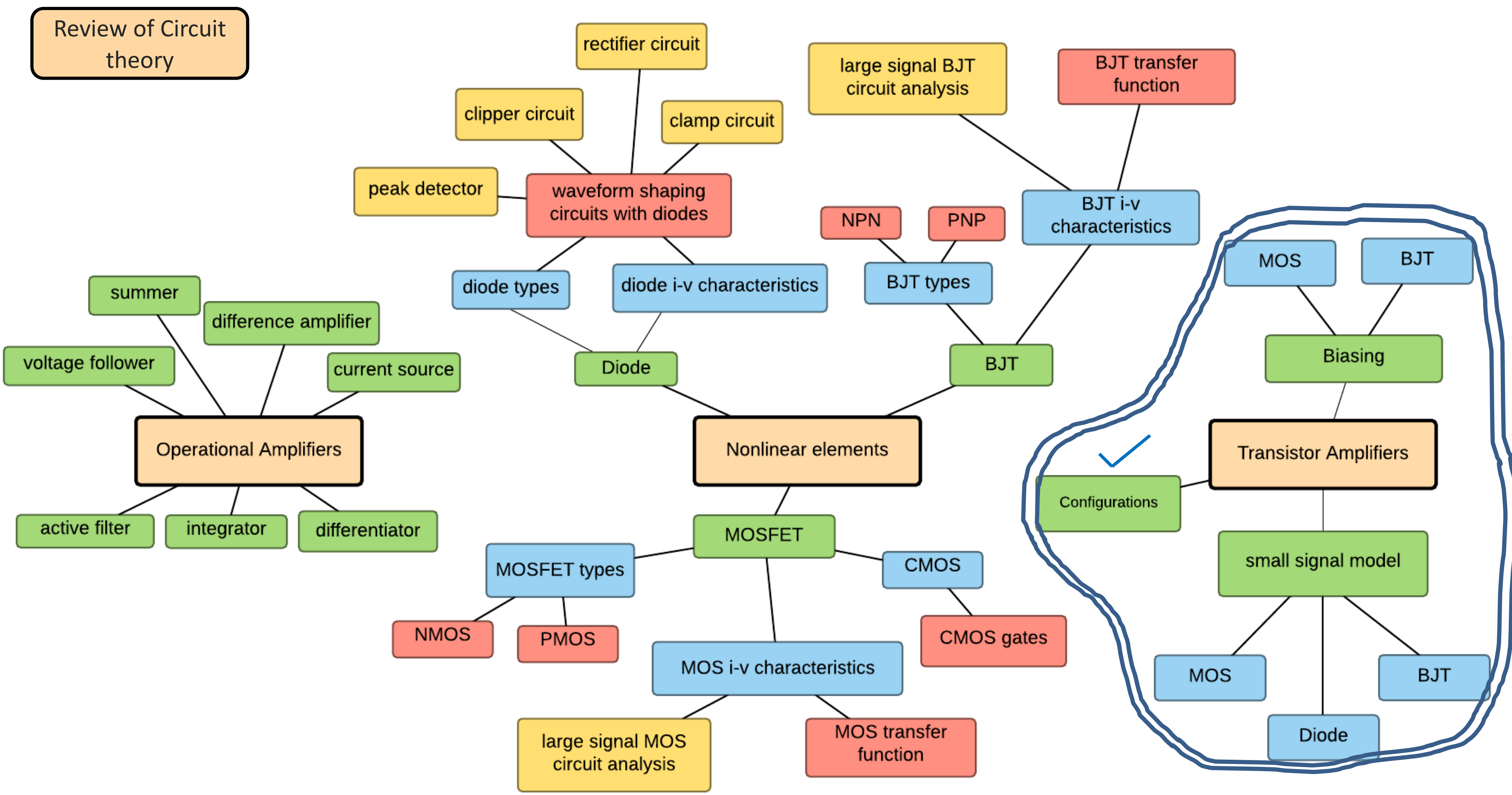
Reference notes: sections 6.1, 6.2

Sedra & Smith (7^{th} Ed): section 7.3

Saharnaz Baghdadchi

Course map

7. Transistor Amplifier Configurations



Practice problem 1.

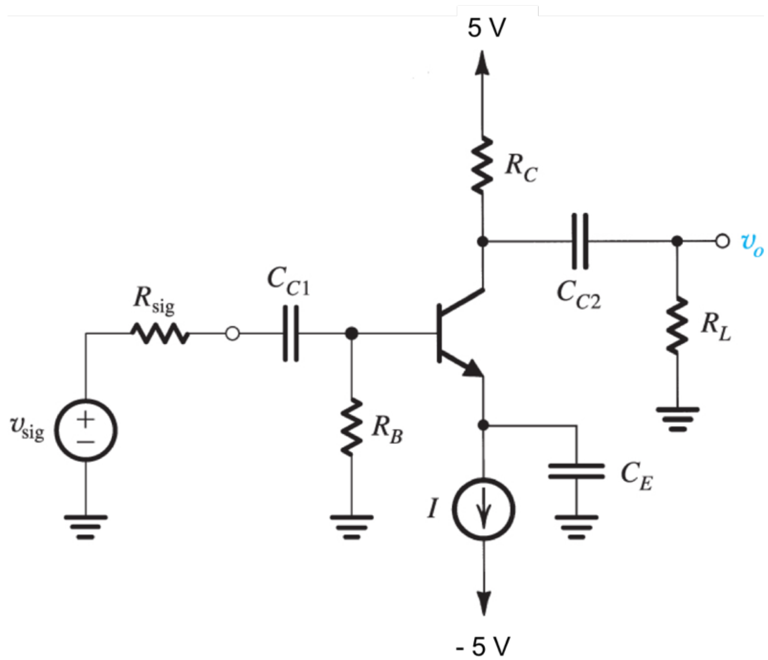
The below BJT amplifier circuit is biased with a constant current source (I). Design the circuit (find I, R_B, and R_C) to meet the following specifications:

a) $R_i = 10\ k\Omega$.

b) The DC voltage drop across R_B is 0.2 V.

c) The open loop voltage gain of the amplifier (A_{Vo}) is -160 V/V.

Assume $\beta = 100, V_{D0} = 0.7\ V, V_A = \infty, V_T = 25\ mV$ and the capacitors are short for the signal circuit.

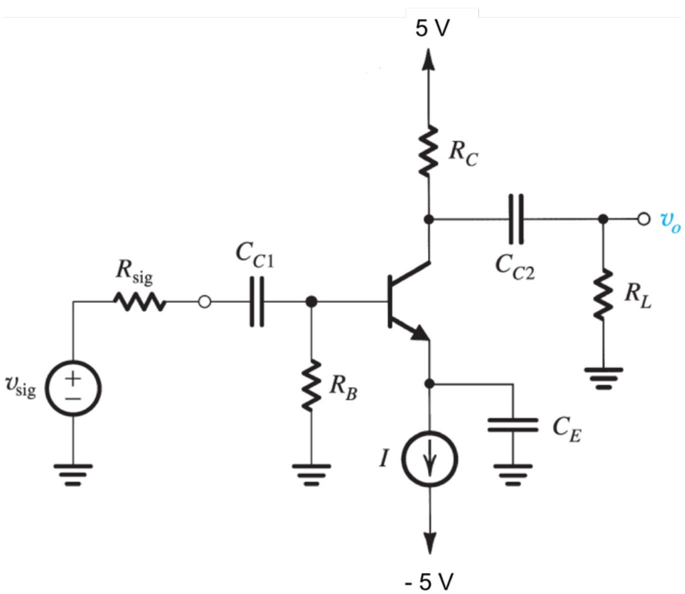


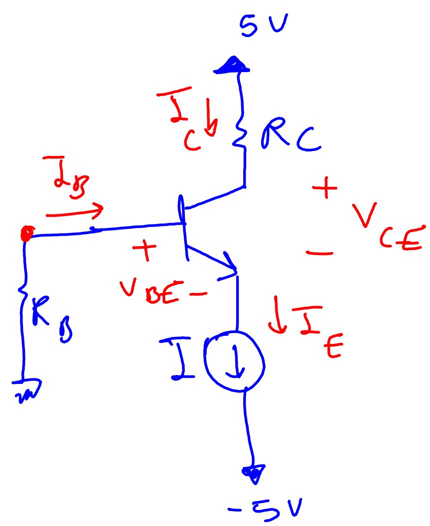
Practice problem 1.

a) $R_i = 10\ k\Omega.$ $R_i = R_B \parallel r_\pi$

b) The DC voltage drop across R_B is 0.2 V.

c) The open loop voltage gain of the amplifier (A_{Vo}) is -160 V/V.





a) $R_B \parallel r_\pi = R_B \parallel \dfrac{V_T}{I_B} = 10\ k\Omega$

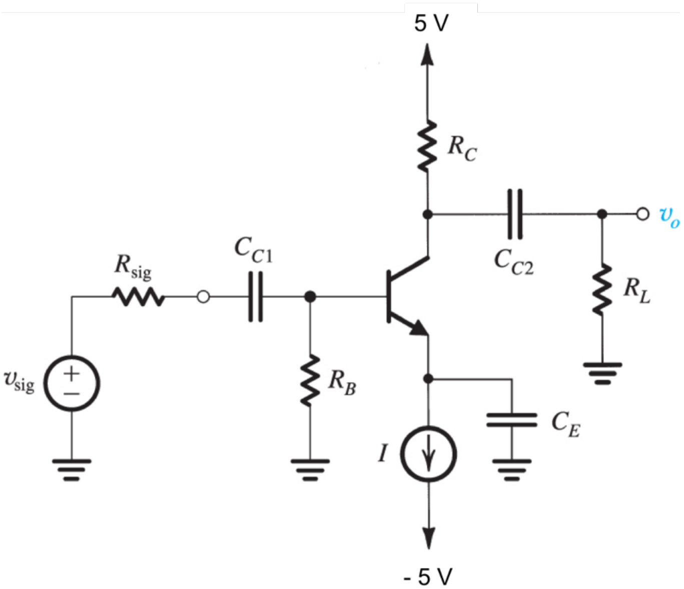
b) $R_B I_B = 0.2\ V$

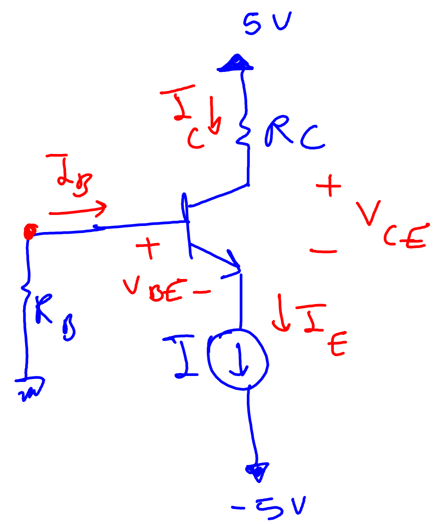
Practice problem 1.

a) $R_i = 10\ k\Omega.$ $R_i = R_B \| r_\pi$

b) The DC voltage drop across R_B is 0.2 V.

c) The open loop voltage gain of the amplifier (A_{Vo}) is -160 V/V.





a) $R_B \| r_\pi = R_B \| \dfrac{V_T}{I_B} = 10k\Omega \longrightarrow \dfrac{R_B \times \dfrac{25mV}{I_B}}{R_B + \dfrac{25mV}{I_B}} = 10k\Omega$

b) $R_B I_B = 0.2V$

Practice problem 1.

a) $R_i = 10\ k\Omega.$

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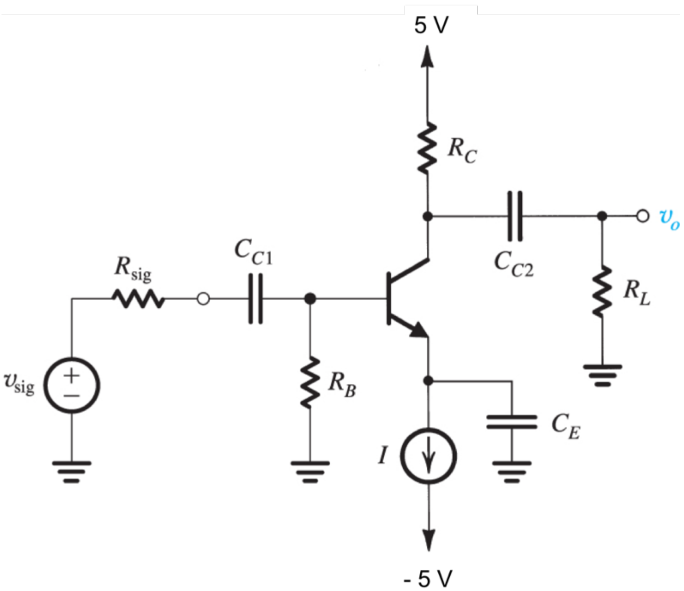

a) $0.025 \dfrac{R_B}{I_B} = 10^4 R_B + \dfrac{250}{I_B}$

$0.025 R_B = 10^4 R_B I_B + 250$

b) $R_B I_B = 0.2V$

$R_B = 90\ k\Omega$

$I = 0.22 mA$

$I = I_E = (1+\beta) I_B$

Practice problem 1.

$$I_E = \frac{1+\beta}{\beta} I_C$$

a) $R_i = 10\ k\Omega.$

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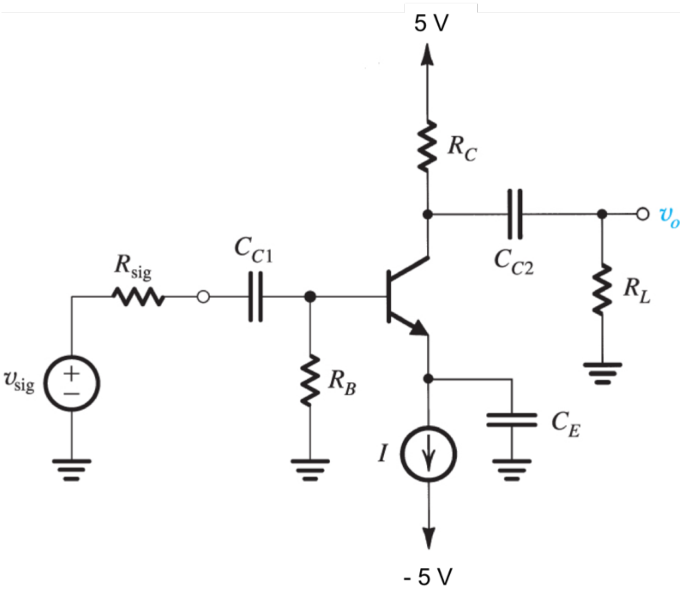
c) The open loop voltage gain of the amplifier (A_{Vo}) is -160 V/V.



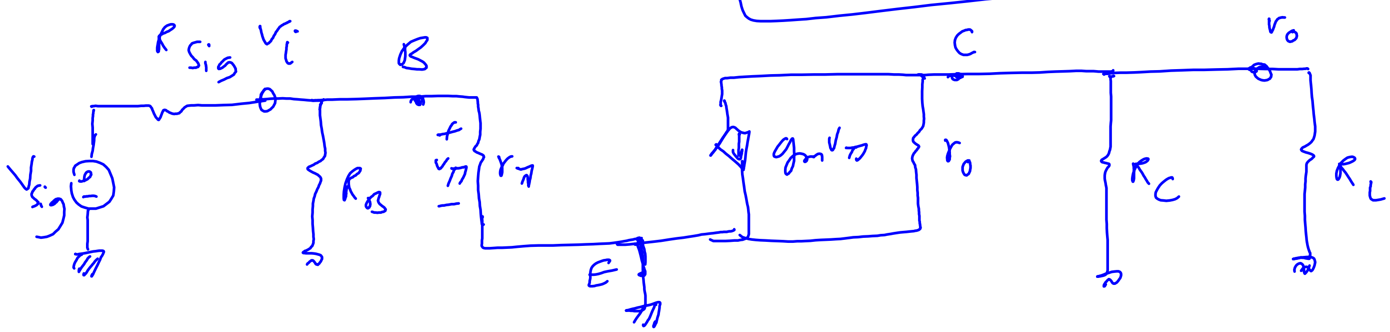
$$A_{v_o} = -g_m (R_C \parallel r_o)$$

$$r_o = \infty$$

$$A_{v_o} = -g_m R_C = -160\ V/V$$

$$g_m = \frac{I_C}{V_T} = \frac{0.22\,mA}{25\,mV} = 8.89\ mA/V$$

$$\boxed{R_C = 18\,k\Omega}$$



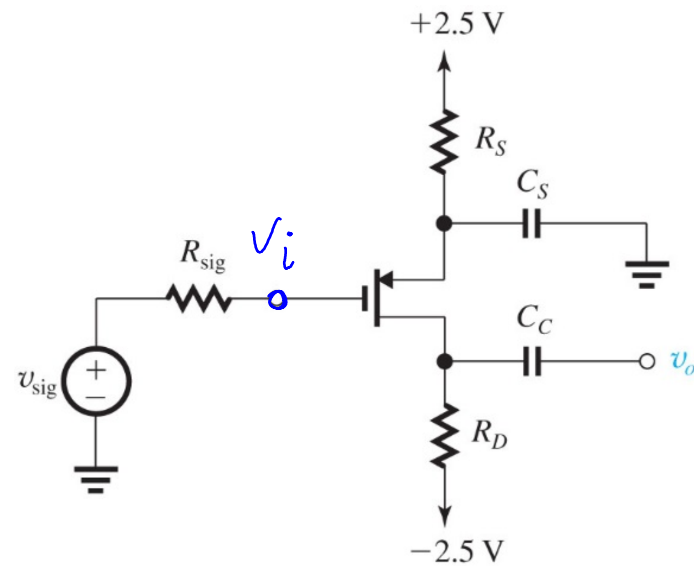
Practice Problem 2.

Amplifier design problem

The PMOS in the below common-source amplifier circuit has $V_{tp} = -0.7\ V$ and $\lambda = 0$.

1. Select a value for R_S to bias the transistor at $I_D = 0.3\ mA$ and $V_{OV} = 0.3\ V$.

2. Select a value for R_D that results in $A_V = -10\ V/V$.



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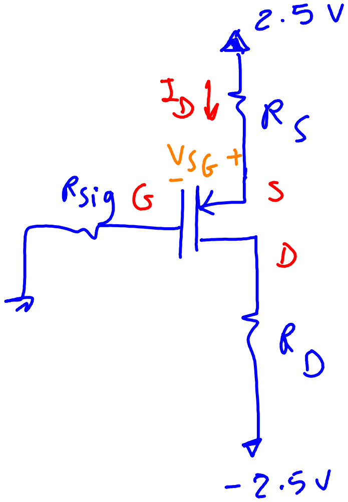
Bias circuit:



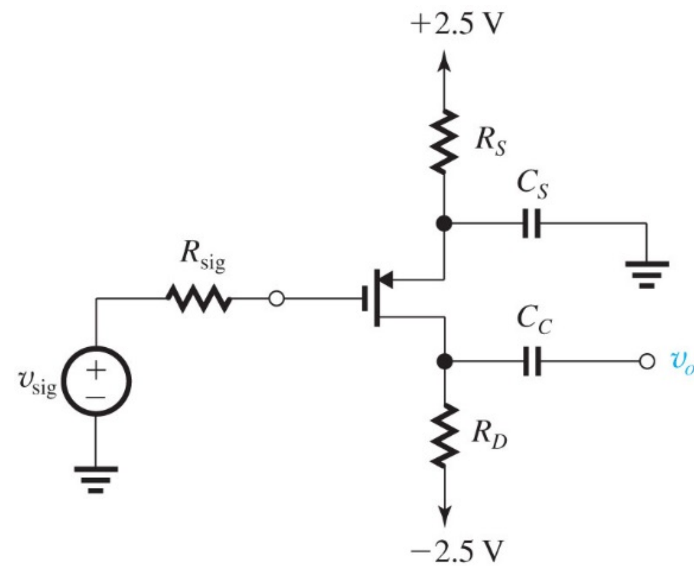
Since $I_G = 0 \rightarrow V_G = 0$

$V_{OV} = V_{SG} - |V_{tp}|$

$V_{SG} = 0.3\,V + 0.7\,V = 1\,V$

$V_{SG} = V_S - V_G = V_S = 1\,V$

$\boxed{V_S = 1V} \longrightarrow R_S = \dfrac{2.5V - 1V}{0.3\,mA} = 5\,k\Omega$



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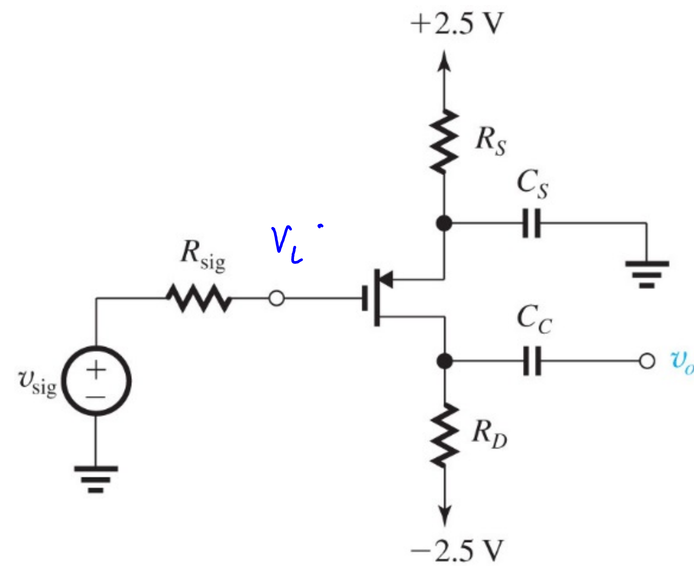
$$A_{v_o} = -g_m R_D = -10\ V/V$$

$$g_m = \frac{2 I_D}{V_{OV}} = \frac{2 \times 0.3 mA}{0.3 V} = 2\ mA/V$$

$$2\ (mA/V)\ R_D = 10 \longrightarrow \boxed{R_D = 5 k\Omega}$$



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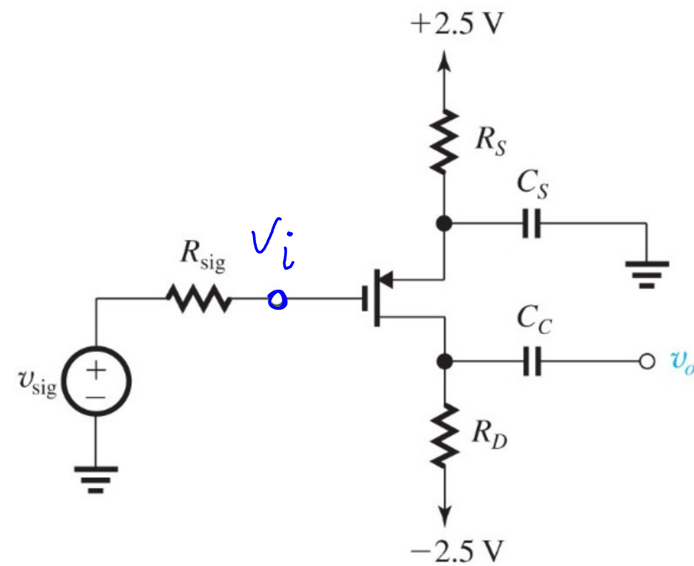
2. Select a value for R_D that results in $A_V = -10\ V/V$.

3. If $v_{sig} = 5 \sin(\omega t)$ (mV) and $R_{sig} = 1k\Omega$, find and sketch all node voltages & i_D.



DC node voltages and DC drain current:

$V_S = 1V$, $V_G = 0V$, $I_D = 0.3\ mA$

$V_D = R_D I_D - 2.5\ V = 5k\Omega \times 0.3mA - 2.5 = -1\ V$

Practice Problem 2.

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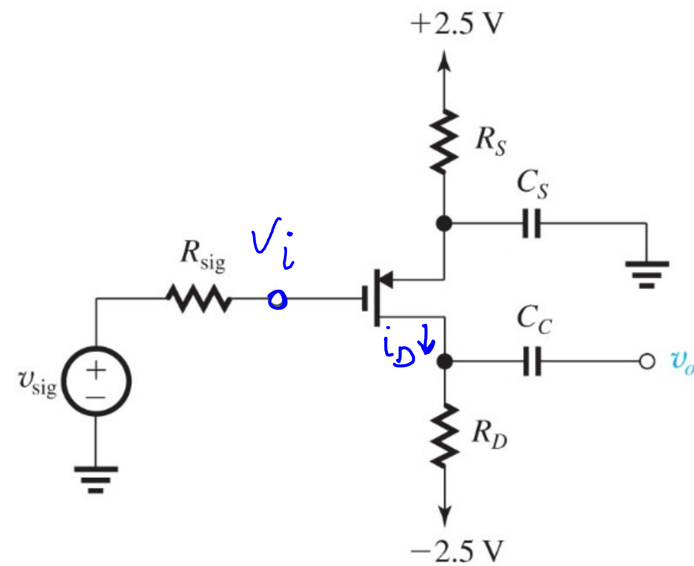
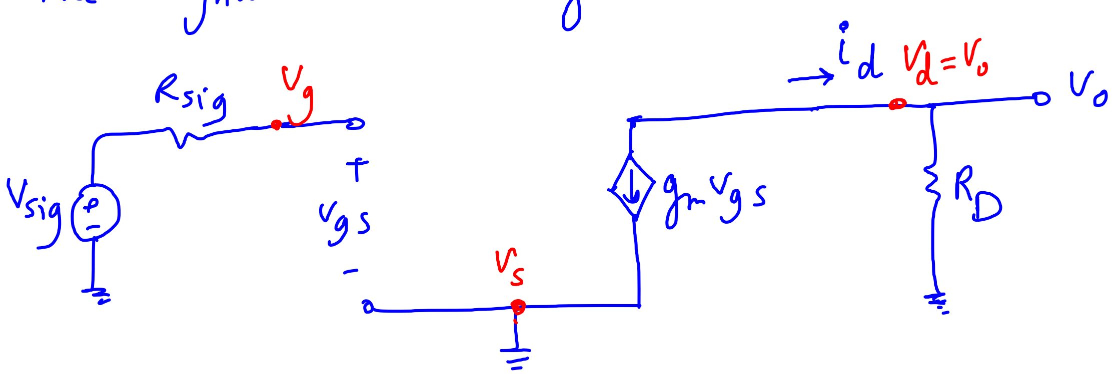


The signal node voltages & currents:



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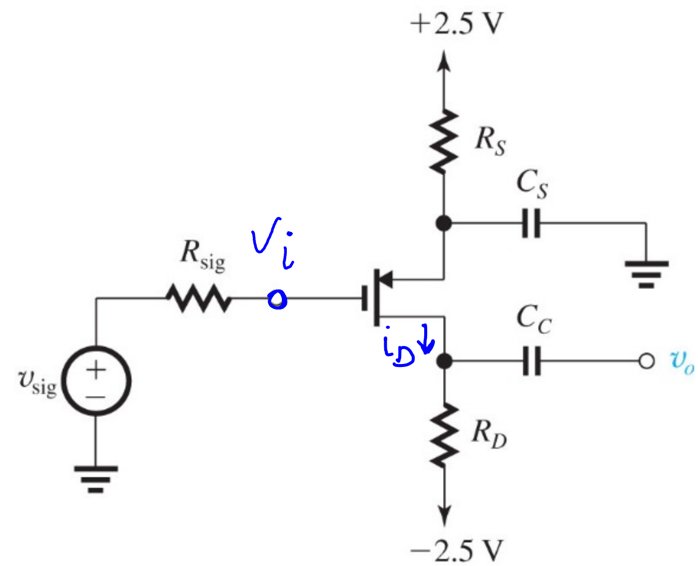

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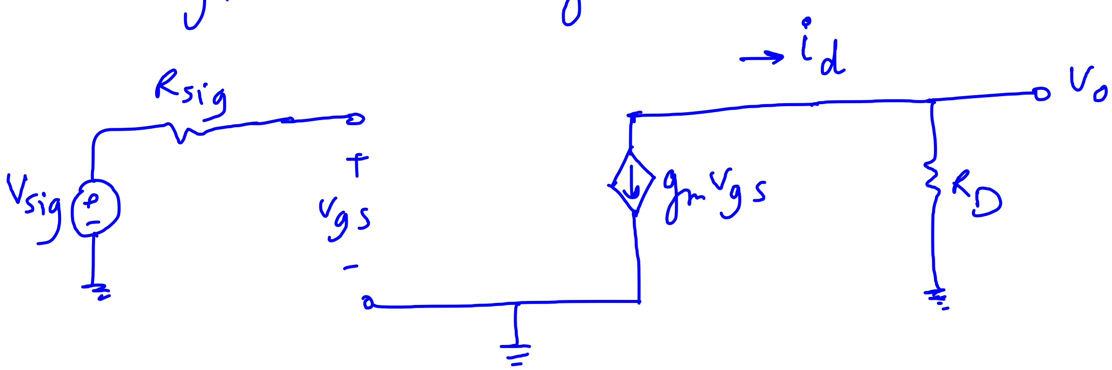

$V_s = 0$, $V_g = V_{sig}$

$V_d = V_o = V_{sig} \times -10\ V/V = -10\ V_{sig}$,

$\boxed{i_d = -g_m V_{gs} = -g_m V_{sig} = -2\ V_{sig}\ (mA)}$

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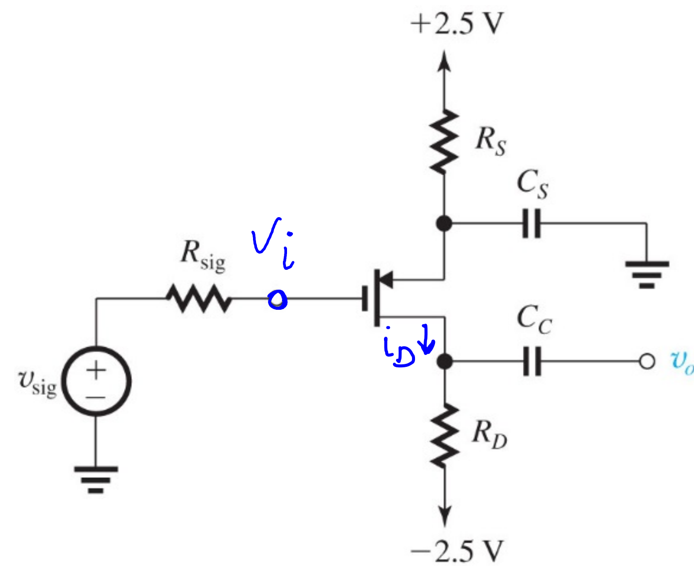
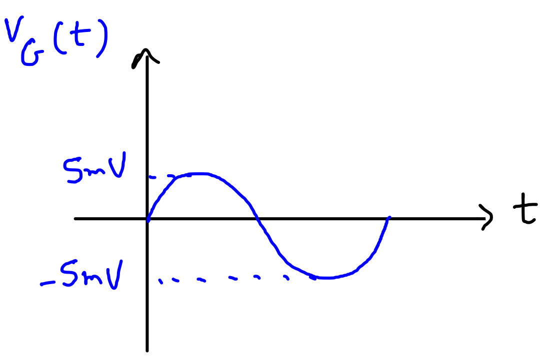
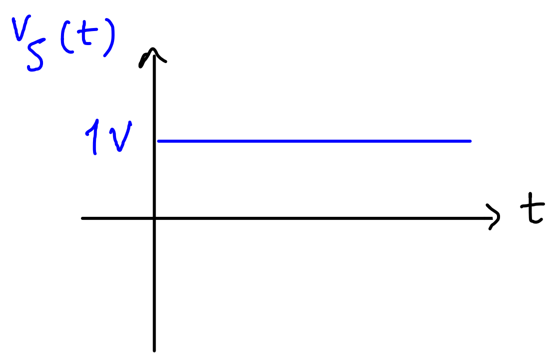
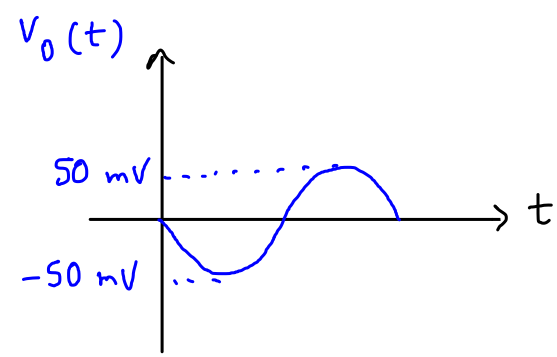


$v_s = 0$, $v_g = v_{sig}$, $v_d = v_o = -10\ v_{sig}$, $i_d = -2\ v_{sig}$ (mA)







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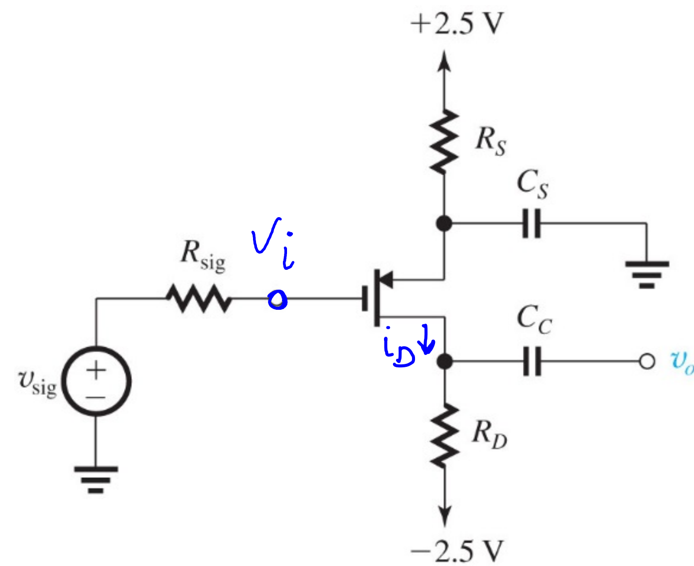

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