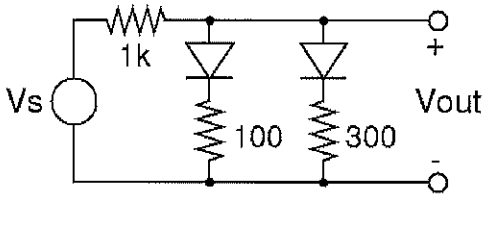
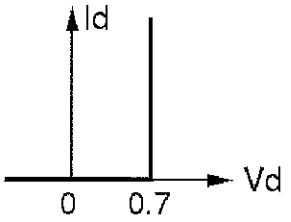
Note: *Only solve **4 of the 5** problems given!*

Name: .....

1) **Diode Application**





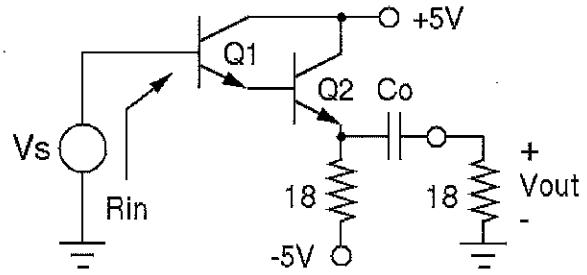
a) Find a value for the current $\mathbf{I_S}$ flowing through the **1 kΩ** resistor if $\mathbf{V_S}$ is a **dc voltage** of **5 V**.

b) Determine the **maximum value** of $\mathbf{V_{out}}$ if $\mathbf{V_S}$ is a **sinusoidal voltage** of **5V** amplitude.

c) What is the **minimum value** of $\mathbf{V_{out}}$ for the operating conditions given in b)?

d) Based on the given diode model, we can replace the 2 diode branches by a **single branch** comprising **one** diode in series with a resistor R_x. What is the **value** of this equivalent resistor $\mathbf{R_x}$?

2) **Cascade of two CC Gain Stages**



Transistors are identical
β=100
$V_A = \infty$
$nV_T = 30$ mV

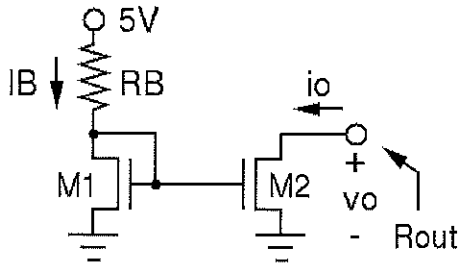
a) Find a value for the **dc collector current** $\mathbf{I_{C2}}$ of **Q2** if V_s is an **ideal ac source** (To simplify matters, you can assume that **both transistors** feature the same **base-emitter voltage** of **0.7 V**).

b) What is the **actual difference** $\mathbf{\Delta V_{BE}}$ of the two **base-emitters voltages** if we know that Q2 carries **100 times** more current than Q1 but also features a **4 times higher** saturation current **Is** due to an elevated junction temperature? (Hint: You can neglect the change in V_T for this calculation since it has little impact).

c) Find a value for the **maximum ac output swing** (amplitude in V) of this circuit? (Assume that the cap C_o acts as an ac short)

d) Find the numerical value of the **input resistance** $\mathbf{R_{in}}$ (C_o acts as an ac short).

3) **MOSFET Current Mirror**



Transistors are identical
$\mu C_{ox}W/L = 400\ \mu A/V^2$
$V_t = 0.8\ V$
$\lambda = 0.02\ V^{-1}$

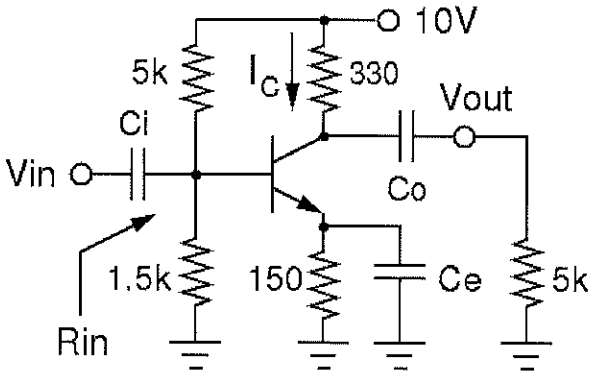
a) Find **RB** such that M1 features a **dc drain current I_B** of **100 μA**.

b) Find the **minimum value of V_o** that keeps **both transistors** in **saturation.**

c) Derive a numerical **value for the output resistance R_{out}.**

d) By **how much** would **R_{out} increase** if you were to switch a resistance **Rs of 3kΩ** between the source and ground of **each** transistor? (I_B remains at **100 μA**)

4) **BJT Amplifier**



Transistor Parameters:
$V_{BEQ} = 0.7\ V$
$\beta = 100$
$V_A = \infty$
$nV_T = 30\ mV$

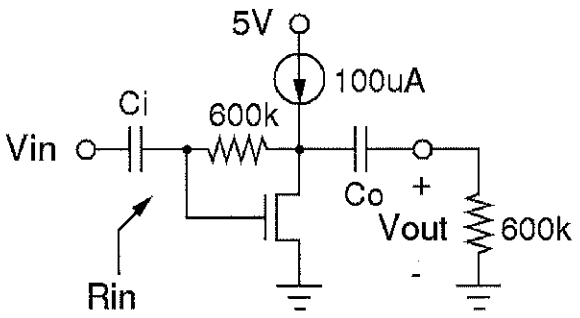
a) What is the value of the **equivalent base resistor RB**?

b) Find the Q-point values **I_{CQ}** and **V_{CEQ}** of the depicted NPN transistor.

c) Sketch the ac equivalent circuit under the assumption that all three **capacitors** represent **shorts for ac** frequencies and find a numerical value for the voltage gain **$A_V = V_{out}/V_{in}$.**

d) Find a value for the **input resistance R_{in} at dc** (C_i is not included in R_{in}).

5) **MOSFET Amplifier**



MOSFET Parameters:
$\mu C_{ox}W/L = 800\ \mu A/V^2$
$V_t = 0.8$ V
$\lambda = 0.02$

a) Find the **dc value** of the **drain voltage V_D** of the depicted MOS transistor (Note: the depicted current source is an **ideal dc source**).

b) Sketch the **small signal or ac equivalent circuit** under the assumption that both **capacitors** represent **ac shorts**.

c) Derive a **symbolic expression** and a numerical value for the voltage gain **$A_V=V_{out}/V_{in}$**.

d) Find a numerical value for the input resistance (Recall that Co acts as a short for ac frequencies).