Homework 11

1. **SRAM cell**: This problem concerns SRAM cells (SRAM = static random access memory).
   (a) Draw the circuit diagram of a BJT SRAM cell consisting of two BJTs and four resistors. Give a formula for the approximate power consumption of the cell.
   (b) Draw the circuit diagram of a CMOS FET SRAM cell consisting of four FETs. What is the status power consumption of the cell?
   (c) What do you conclude from the comparison of BJT-based and FET-based SRAM cells?

2. **CMOS inverter circuit**: The present problem concerns a basic digital CMOS circuit: A CMOS inverter having two transistors and no resistors.
   (a) Draw the circuit diagram of the CMOS inverter consisting of two FETs and no resistor. Explain how the inverter works.
   (b) Explain why the AC small-signal equivalent circuit is of little or no interest in the present context.
   (c) We generally differentiate between static power consumption (DC power consumption) and dynamic power consumption (power consumption due to the charging of parasitic capacitors, e.g. gate capacitors). What is the static power consumption of a CMOS inverter circuit?
   (d) Explain why CMOS FET circuits are very **suitable** for large-scale integrated circuits.
   (e) Explain why BJT circuits are very **unsuitable** for large-scale integrated circuits.

3. **CMOS inverter circuit**: Consider the inverter circuits shown below. The LHS (left-hand side) circuit has a transistor T_1 and a load resistor. The RHS (right-hand side) circuit has two transistors, T_1 and T_2. The inverter circuits have two possible input voltages $+V_{CC}$ and zero (GND); the corresponding output voltages are zero (GND) and $+V_{CC}$, respectively.
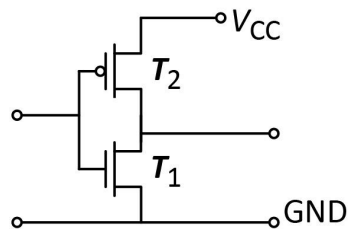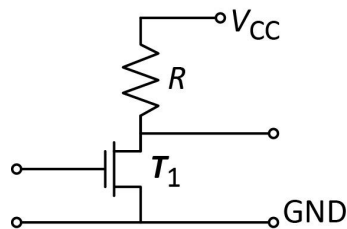
   (a) Consider the LHS circuit. Draw the general output characteristic of transistor T_1 (I_D-versus-V_{DS}). Mark a 1st state (point) in the transistor's output characteristic when the input is zero. Then mark a 2nd state (point) in the transistor's output characteristic when the input is $+V_{CC}$.
   (b) Next consider the RHS circuit. Draw the general output characteristic of transistor T_1 (I_D-versus-V_{DS}). Mark a 1st state (point) in the transistor's output characteristic when the input is zero. Then mark a 2nd state (point) in the transistor's output characteristic when the input is $+V_{CC}$.
   (c) Compare the two circuits and describe your observations.

4. ***True / false questions***: Are the following statements true or false? Explain your answer with one or two sentences.

   (a) Although BJT integrated circuits are faster than FET integrated circuits, the vast majority of integrated circuits are made from FETs.

   (b) Satellite receivers frequently have front-end amplifiers made with FETs, because signals received on Earth from outer-space satellites are inherently weak.