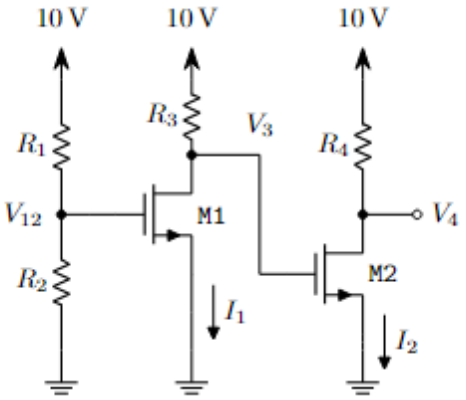
Relevant information for the circuit configuration on the right is given in the tables below:

Resistor values in (kΩ)

R_1	R_2	R_3	R_4
3	5	2	4

Transistor Parameters

$k_n = 2\,\text{mA/V}^2$
$V_T = 1\,\text{V}$



(a) **[CO1] Draw** the IV-characteristics of a MOSFET using S-model with proper labeling. [1]

(b) **[CO2] Determine** the value of V_{12}. [1]

(c) **[CO2] Calculate** the value of drain-to-source voltage of the transistor `M1`. In the process, determine the operating mode of `M1`. [3.5]

(d) **[CO2] Determine** which one of the four resistors will consume the least amount of power. [**Hint**, Power $= I^2R$] [3]

(e) **[CO2] Determine** how the operating mode of `M2` would change if R_2 were set to zero. [1.5]

Solution:

$$V_{12} = \frac{R_2 \times 10}{R_2 + R_1} = 6.25\,\text{V}$$

Solution: For **triode** mode of operation:

$$V_{OV} = V_{GS} - V_T = 5.25\,\text{V}$$

$$I_1 = \frac{10 - V_3}{R_3} = k(V_{OV}V_3 - \frac{V_3^2}{2})$$

$$\frac{10 - V_3}{2} = 2(5.25V_3 - \frac{V_3^2}{2})$$

$$\frac{1}{2}V_3^2 - 5.5V_3 + 2.5 = 0$$

$$V_3 = 0.48\,\text{V} < V_{OV}$$

So, the MOSFET is operating in **triode** mode.

Solution: As $V_3 = 0.48\,\text{V} < V_T$, the MOSFET `M2` is in **cut-off**. So, $I_2 = 0$. So, no power is consumed by R_4. Therefore, R_4 consumes the least power.

Solution: When $R_2 = 0\,\Omega$, the MOSFET `M1` is in **cut-off** as the gate terminal is shorted to ground. So, $V_3 = 10\,\text{V}$. So, the MOSFET `M2` would change it's mode from **cut-off** to **triode**.