The circuit shown below is the MOS version of a Wilson current mirror. Assume all transistors are exactly matched and biased in the saturation region. This results in a very good current matching. In other words $I_{\text{OUT}}=I_{\text{IN}}$ to a very high degree of accuracy.

$I_{\text{IN}}=I_{\text{OUT}}=50\mu\text{A}$. The over-voltage ($V_{\text{ov}}$, or $v_{gs}-V_t$) is $100\text{mV}$ and the threshold voltage $V_t$ is $300\text{mV}$ for all devices. The Early voltage $V_A$ is $10\text{V}$.

Useful small signal parameters are: $g_m=2I_D/V_{ov}$, and $r_c=V_A/I_D$.

1) What is the minimum voltage $V_{\text{OUT}}$ that can be tolerated to ensure operation as a current source? (1 point)

2) What is the output resistance of this current source? Develop both an expression and determine a numerical value for the resistance. (3 points)

A useful approximation, which greatly simplifies the analysis of question 2, is to ignore the output resistance of the two diode-connected transistors ($M_4$ and $M_1$). Other than that this is best solved by the usual method of applying a test source to the output.