1) Find the voltage source equivalent and current source equivalent circuits for the following circuits at nodes A-B.
5.4 An NMOS transistor that is operated with a small $v_{DS}$ is found to exhibit a resistance $r_{DS}$. By what factor will $r_{DS}$ change in each of the following situations?

(a) $V_{OV}$ is doubled.
(b) The device is replaced with another fabricated in the same technology but with double the width.
(c) The device is replaced with another fabricated in the same technology but with both the width and length doubled.
(d) The device is replaced with another fabricated in a more advanced technology for which the oxide thickness is halved and similarly for $W$ and $L$ (assume $\mu_c$ remains unchanged).

5.9 An NMOS transistor with $k_n = 1 \text{ mA/V}^2$ and $V_r = 1 \text{ V}$ is operated with $V_{GS} = 2.5 \text{ V}$. At what value of $V_{DS}$ does the transistor enter the saturation region? What value of $I_D$ is obtained in saturation?

5.12 With the knowledge that $\mu_p = 0.4 \mu_n$, what must be the relative width of $n$-channel and $p$-channel devices if they are to have equal drain currents when operated in the saturation mode with overdrive voltages of the same magnitude?

5.34 An NMOS transistor is fabricated in a 0.8-$\mu$m process having $k'_n = 130 \mu\text{A/V}^2$ and $V_A' = 20 \text{ V/\mu m}$ of channel length. If $L = 1.6 \mu$m and $W = 16 \mu$m, find $V_A$ and $\lambda$. Find the value of $I_D$ that results when the device is operated with an overdrive voltage of 0.5 V and $V_{DS} = 2 \text{ V}$. Also, find the value of $r_D$ at this operating point. If $V_{DS}$ is increased by 1 V, what is the corresponding change in $I_D$?

5.39 A $p$-channel transistor for which $|V_A| = 1 \text{ V}$ and $|V_A'| = 50 \text{ V}$ operates in saturation with $|V_{GS}| = 3 \text{ V}$, $|v_{DS}| = 4 \text{ V}$, and $i_D = 3 \text{ mA}$. Find corresponding signed values for $v_{GS}$, $v_{SD}$, $v_{DS}$, $v_{SD'}$, $V_r$, $V_A$, $\lambda$, and $k_p(W/L)$.

5.76 For the NMOS amplifier in Fig. P5.76, replace the transistor with its T equivalent circuit, assuming $\lambda = 0$. Derive expressions for the voltage gains $v_s/v_i$ and $v_d/v_i$.

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Figure P5.76