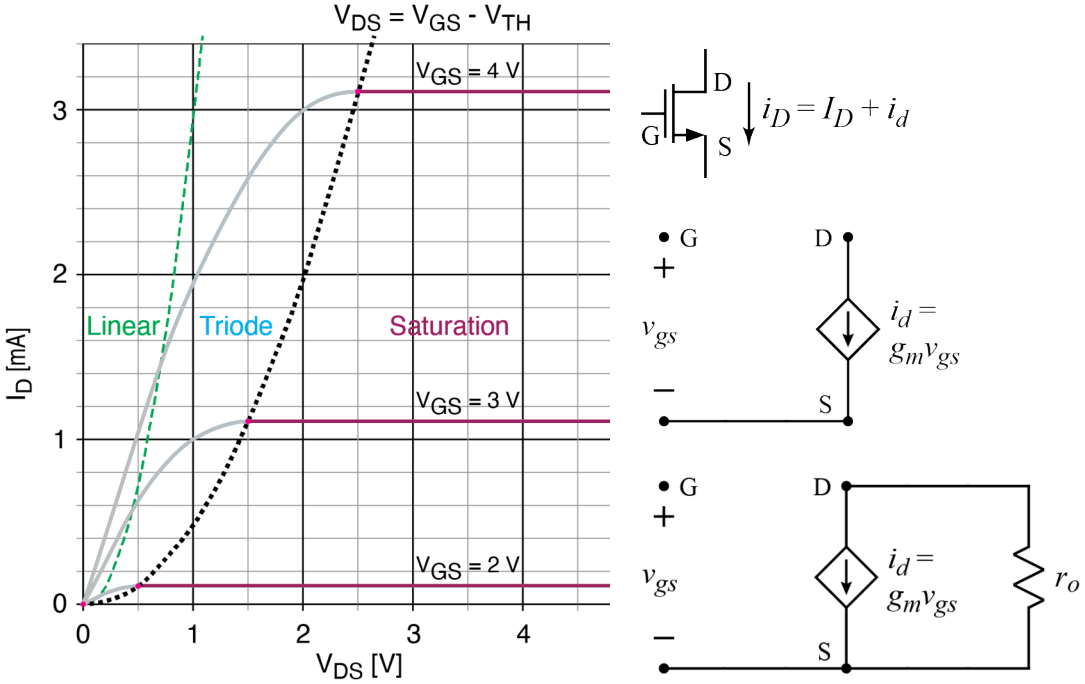

TOOL: Consider an NMOS FET with channel modulation.

Transconductance parameter	k_n
Threshold	V_{TH}
Channel modulation	λ

Note: Formulas apply in general.

Example characteristic curves shown: $k_n = 1\,\text{mA/V}^2$, $V_{TH} = 1.5\,\text{V}$, $\lambda = 0.02\,\text{V}^{-1}$



MODEL: (Sat) Without channel modulation: $I_D = \frac{k_n}{2}(V_{GS} - V_{TH})^2$

$$i_d = g_m v_{gs}$$

$$g_m = \frac{dI_D}{dV_{GS}} = k_n(V_{GS} - V_{TH}) = \frac{2I_D}{V_{GS} - V_{TH}} = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D}$$

$r_o = \infty\,\Omega$ (omitted from schematic)

With channel modulation: $I_{Dmod} = \frac{k_n}{2}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$

$$i_{dmod} = g_m v_{gs} + v_{ds}/r_o$$

$$g_m = \frac{dI_{Dmod}}{dV_{GS}} = k_n(V_{GS} - V_{TH})(1 + \lambda V_{DS}) = \frac{2I_{modD}}{V_{GS} - V_{TH}}$$

$$r_o = \frac{1}{\frac{dI_{Dmod}}{dV_{DS}}} = \frac{1}{\lambda I_{Dmod}} = \frac{V_A}{I_{Dmod}}$$ where V_A is from data sheet