**10.49** Consider the p-channel MOSFET described in Problem 10.38. (*a*) Calculate $g_{mL}$ for $V_{SD} = 0.10$ V. (*b*) Find $g_{ms}$ for $V_{SG} = 1.5$ V.

- First, find $K_p$.

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**10.38** Consider an ideal p-channel MOSFET with the following parameters: $V_T = -0.35$ V, $\mu_p = 210$ cm$^2$/V-s, $t_{ox} = 11$ nm $= 110$ Å, $W = 35$ $\mu$m, and $L = 1.2$ $\mu$m.

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From Table B.6, $\varepsilon_r = 3.9$ for $SiO_2$ at 300 K.

**Linear Region** [$0 \le V_{SD} \le V_{SD}$(sat) **and** $V_{SG} > V_T$]

$$I_D = \frac{W\mu_p C_{ox}}{2L}\left[2(V_{SG}+V_T)V_{SD} - V_{SD}^2\right] = K_p\left[2(V_{SG}+V_T)V_{SD} - V_{SD}^2\right] \quad (10.70).$$

**Saturation** [$V_{SG} \ge V_T$ & $V_{SD} \ge V_{DS}$(sat)]

$$I_D(\text{sat}) = \frac{W\mu_p C_{ox}}{2L}\left(V_{SG}+V_T\right)^2 = K_p\left(V_{SG}+V_T\right)^2 \quad (10.72)$$

From above or page 416 of text (use MKS units),

$$K_p = \frac{W\mu_p C_{ox}}{2L} = \frac{35\times10^{-6}(210\times10^{-4})\,3.9(8.8541878\times10^{-12})/11\times10^{-9}}{2(1.2\times10^{-6})}$$

$\Rightarrow$ **$K_p = 9.61384\times10^{-4}$ A/V$^2$ = 0.961384 mA/V$^2$.**

For a p-channel MOSFET, the transconductance is $g_m = \dfrac{\partial I_D}{\partial V_{SG}}$.

a) In the linear region w/ $V_{SD} = 0.1$ V,

$$g_{mL} = \frac{\partial K_p\left[2(V_{SG}+V_T)V_{SD} - V_{SD}^2\right]}{\partial V_{SG}} = 2K_p(1+0)V_{SD} - 0$$

$$= 2K_pV_{SD} = 2(0.961384)0.1$$

$\Rightarrow$ **$g_{mL}$ = 0.19228 mA/V.**

b) In the saturation region w/ $V_{SD} = 1.5$ V,

$$g_{mS} = \frac{\partial K_p\left(V_{SG}+V_T\right)^2}{\partial V_{SG}} = 2K_p\left(V_{SG}+V_T\right)(1+0)$$

$\Rightarrow$ **$g_{mS}$ = 2.2112 mA/V.**

$$= 2(0.961384)(1.5-0.35)$$