10.36 Consider a p-channel MOSFET with the following parameters: $k_p' = 0.12$ mA/V^2 and $W/L = 20$. The drain current is 100 μA with applied voltages of $V_{SG} = 0$, $V_{BS} = 0$, and $V_{SD} = 1.0$ V. (*a*) Determine the V_T value. (*b*) Determine the drain current I_D for $V_{SG} = 0.4$ V, $V_{SB} = 0$, and $V_{SD} = 1.5$ V. (*c*) What is the value of I_D for $V_{SG} = 0.6$ V, $V_{SB} = 0$, and $V_{SD} = 0.15$ V?

(10.71) $I_D = \frac{K_p'}{2}\frac{W}{L}\left[2(V_{SG}+V_T)V_{SD} - V_{SD}^2\right]$ linear

for $V_{SG} > V_T$ and $V_{SD} < V_{SG} + V_T$

(10.73) $I_D = \frac{K_p'}{2}\frac{W}{L}(V_{SG}+V_T)^2$ saturation

for $V_{SG} > V_T$ and $V_{SD} \geq V_{SG} + V_T$

a) Assume saturation since $V_{SD} = 1V$ and $V_{SG} = 0$

$$100\times10^{-6} = \frac{0.12\times10^{-3}}{2}(20)(0+V_T^2)$$

$$\hookrightarrow \underline{\underline{V_T = 0.288675\ V}}$$

b) $V_{SD} = 1.5V > 0.4 - 0.2887$ (saturation)

$$I_D = \frac{0.12\times10^{-3}}{2}20(0.4+0.288675)^2$$

$$\underline{\underline{I_D = 0.5691\ mA}}$$

c) $V_{SD} = 0.15V < 0.6 - 0.2887 = 0.31V$ (linear)

$$I_D = \frac{0.12\times10^{-3}}{2}(20)\left[2(0.6+0.288675)0.15 - 0.15^2\right]$$

$$\underline{\underline{I_D = 0.2929\ mA}}$$