10.33 Consider an n-channel MOSFET with the following parameters: $k_n' = 0.18$ mA/V^2, $W/L = 8$, and $V_T = 0.4$ V. Determine the drain current I_D for (*a*) $V_{GS} = 0.8$ V, $V_{DS} = 0.2$ V; (*b*) $V_{GS} = 0.8$ V, $V_{DS} = 1.2$ V; (*c*) $V_{GS} = 0.8$ V, $V_{DS} = 2.5$ V; and (*d*) $V_{GS} = 1.2$ V, $V_{DS} = 2.5$ V.

(10.44b) $I_D = \frac{K_n'}{2}\frac{W}{L}\left[2(V_{GS}-V_T)V_{DS} - V_{DS}^2\right]$

for $V_{GS} > V_T$ and $V_{DS} < V_{GS} - V_T$

(10.45b) $I_D = \frac{K_n'}{2}\frac{W}{L}(V_{GS}-V_T)^2$ for $V_{GS} > V_T$ + $V_{DS} \geq V_{GS} - V_T$

a) $V_{GS} > V_T$ and $V_{DS} < V_{GS} - V_T$ (linear)

$I_D = \frac{0.18\text{mA}}{2\text{V}^2} 8\left[2(0.8-0.4)0.2 - 0.2^2\right]$

$\underline{I_D = 0.0864\text{ mA} = 86.4\ \mu\text{A}}$

b) $V_{GS} > V_T$ but $V_{DS} > V_{GS} - V_T$ (saturation)

$I_D = \frac{0.18\text{ mA}}{2\text{ V}^2} 8(0.8-0.4)^2 \Rightarrow \underline{I_D = 0.1152\text{ mA}}$

c) $V_{GS} > V_T$ but $V_{DS} > V_{GS} - V_T$ (saturation)

$I_D = \frac{0.18\text{ mA}}{2\text{ V}^2} 8(0.8-0.4)^2 \Rightarrow \underline{I_D = 0.1152\text{ mA}}$

d) $V_{GS} > V_T$ and $V_{DS} > V_{GS} - V_T$ (saturation)

$I_D = \frac{0.18}{2} 8(1.2-0.4)^2 \Rightarrow \underline{I_D = 0.4608\text{ mA}}$