ENEE302 WS revised 05/14/02
Solution to hw4, problem 1

Note that the PMOS transistor will operate in saturation for

$$V_{SD} > V_{SG} - |V_t| \quad \text{, i.e. } V_{SD} > V_{SG} - 1$$

Otherwise, it operates in the triode region.
Then, observe that $V_{SD} = V_{SG} - IR$.
Thus as long as $IR \le |V_t|$, the transistor will be in saturation.

For R = 0, IR = 0, and the MOSFET is saturated. Then

$$\text{I} = 100 = \frac{1}{2} * 8 * 25(V_{SG} - |V_t|)^2$$

$$V_{SG} - |V_t| = 1$$

$$V_{SG} = 2 \text{ V} \quad V_{SD} = V_{SG} = 2 \text{ V}$$

For R = 30 kΩ, IR = 3 V and the transistor will be operating in the triode region, then

$$100 = 8 * 25\left[(V_{SG} - |V_t|)(V_{SD}) - \frac{1}{2} V_{SD}^2 \right]$$

$$= 200\left[(V_{SG} - 1)(V_{SG} - 3) - \frac{1}{2}(V_{SG} - 3)^2 \right]$$

$$0.5 = 0.5V_{SG}^2 - V_{SG} - 1.5$$

$$0.5V_{SG}^2 - V_{SG} - 2 = 0$$

$$V_{SG} = 3.24 \text{ V} \quad V_{SD} = V_{SG} - 3 = 0.24 \text{ V}$$

$V_{SD} = V_{SG} / 2$ obtains when the MOSFET is in the triode region. Thus,

$$100 = 8 * 25\left[(V_{SG} - |V_t|)(V_{SD}) - \frac{1}{2} V_{SD}^2 \right]$$

$$= 200\left[(V_{SG} - 1)\frac{V_{SG}}{2} - \frac{1}{2}\frac{V_{SG}^2}{4} \right]$$

$$0.5 = 0.5V_{SG}^2 - 0.5V_{SG} - V_{SG}^2 / 8$$

$$0.75V_{SG}^2 - V_{SG} - 1 = 0$$

$$V_{SG} = 2 \text{ V} \quad V_{SD} = V_{SG} / 2 = 1 \text{ V}$$

Therefore, $R = \frac{2 - 1}{0.1} = 10 \text{ k}\Omega$