3.2

a.) small signal voltage gain $A_V = -g_{m_1}(r_1 // r_2)$

$$r_1 = \frac{1}{\lambda_n I_D} = \frac{1}{0.1(0.5)} = 20\ \Omega$$

$$r_2 = \frac{1}{\lambda_p I_D} = \frac{1}{0.2(0.5)} = 10\ \Omega$$

$$g_{m_1} = \sqrt{2\mu_n C_{ox}(W/L_1) I_D} \qquad \mu_n C_{ox} = 1.34 \times 10^{-4}$$

$$= \sqrt{2 \cdot 1.34E\text{-}4 \cdot (50/0.5)\, 0.5E\text{-}3}$$

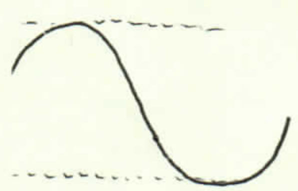
$$\approx 0.0037$$

$$r_1 // r_2 = 20 // 10 = \frac{20 \cdot 10}{20 + 10} \approx 6.67$$

$$A_V = -0.0037 \cdot 6.67 \ \text{V/V}$$

$$A_V = -0.024 \ \text{V/V}$$

b.) maximum output swing given M_1 and M_2 saturated



$V_{DD} - \underbrace{|V_{gs_2} - V_{th_2}|}$ $\rightarrow$ M_2 is at edge of saturation such that $V_{gs_2} = V_{th_2}$

$V_{in} - V_{th_1}$

Find $V_{th_1} \rightarrow$ M_1 is also edge of saturation such that

$V_{in} - V_{th} = V_{DS}$ [gives lower bound of output swing voltage]

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\underbrace{(V_{gs} - V_{th})}_{V_{DS}}^2 (1 + \lambda_n V_{DS})$$

$$I_D = \frac{1}{2} \cdot 1.34E\text{-}4 \cdot \left(\frac{50}{0.5}\right) V_{DS}^2 (1 + 0.1 V_{DS})$$

$$I_D = 0.5E^{-3} \rightarrow 0.00067 V_{DS}^3 + 0.0067 V_{DS}^2 - 0.0005 = 0$$