

**Name:**

**Id#**

**COE 360, Principles of VLSI Design, Term 981  
Quiz# 3**

Date: Wednesday, Nov. 11

**(I)** Assuming nMOS enhancement transistor threshold voltage  $V_{tn}$  of 0.8 V, depletion transistor threshold voltage  $V_{td}$  of -2.0 V, and pMOS enhancement transistor threshold voltage  $V_{tp}$  of -0.9 V, write down the voltages of the indicated nodes below. Assume that the body effect is negligible, and  $W/L=4$  for all transistors.

(II) Given a CMOS inverter with  $\beta_n=2.5\beta_p$ ,  $V_{tn} = 1.0$  V, and  $V_{tp} = -0.8$ V.

1. Show that

$$V_{th} = \frac{V_{tn} + \sqrt{\frac{\beta_p}{\beta_n}}(V_{DD} + V_{tp})}{\left(1 + \sqrt{\frac{\beta_p}{\beta_n}}\right)}$$

2. Compute the value of the inverter threshold,  $V_{th}$

3. For what ratio of  $\beta_n/\beta_p$  the inverter threshold voltage,  $V_{th}=2.5$  Volts.