.model mmod MODE:

- 7.5 For the gate shown in Fig. P7.5,
  - Pull-up transistor ratio is 5/5
  - pull-down transistor ratios are 100/5
  - $V_{m} = 1.0 \text{ V}$
  - $\bullet \, \gamma = 0.4 \, \, \mathrm{V}^{\mathrm{to}}$
  - $|2\phi_{\rm c}| = 0.6 \text{ V}$
  - (a) Identify the worst case input combination(s) for  $V_{oc}$
  - (b) Calculate the worst case value of  $V_{ou}$ . (Assume that all pull-down transistors have the same body bias and initially, that  $V_{ou} = 5\% \ V_{out}$ )

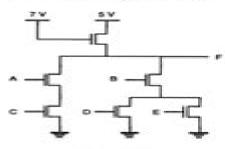


Figure P7.5

#### SOLUTION:

(a) The worst case input combinations are those that cause only one current path from output to ground. The combinations are listed in the following table.

A=1 $C=1$	B=0
A = 1 $C = 1$	C=0 $E=0$
B=1 $D=1$	A=0 $E=0$
B=1 $D=1$	C=0 $E=0$
B=1 $E=1$	A=0 $D=0$
B=1 $E=1$	C = 0 $D = 0$

(b) The worst case equivalent circuit can be represented by a simple inverter, with the driver W/L=10, load W/L=1. Both transistors are operating is linear region in this case because: Driver: V<sub>GS</sub> = 5, V<sub>DS</sub> = 0.25

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Sanjit K. Mitra, Sanjit Kumar Mitra

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