1) \[ C_{BL} = C_d m \ W_3 = 0.5 \ \text{fF} \]

\[ C_{\bar{BL}} = C_{BL} = 0.5 \ \text{fF} \]

\[ C_A = C_{gu} (W_2 + W_6) + C_d m (W_1 + W_3 + W_5) \]

\[ = 3 \ \text{fF} + 2 \ \text{fF} \]

\[ = 5 \ \text{fF} \]

\[ C_B = C_A = 5 \ \text{fF} \]
2.1
\[ \beta = \mu C_{ox} \frac{W}{L} = (350) \left( \frac{3.9 \cdot 8.85 \cdot 10^{-14}}{100 \cdot 10^{-8}} \right) \left( \frac{W}{L} \right) = 120 \frac{W}{L} \mu A/V^2 \]

2.2 In (a), the transistor sees \( V_{gs} = V_{DD} \) and \( V_{ds} = V_{DS} \). The current is
\[ I_{DS1} = \frac{\beta}{2} \left( V_{DD} - V_I - \frac{V_{DS}}{2} \right) V_{DS} \]

In (b), the bottom transistor sees \( V_{gs} = V_{DD} \) and \( V_{ds} = V_1 \). The top transistor sees \( V_{gs} = V_{DD} - V_1 \) and \( V_{ds} = V_{DS} - V_1 \). The currents are
\[ I_{DS2} = \beta \left( V_{DD} - V_I - \frac{V_1}{2} \right) V_I = \beta \left( V_{DD} - V_I - \frac{V_{DS} - V_I}{2} \right) (V_{DS} - V_1) \]

Solving for \( V_I \), we find
\[ V_I = (V_{DD} - V_I) - \sqrt{(V_{DD} - V_I)^2 - \left( V_{DD} - V_I - \frac{V_{DS} - V_I}{2} \right) V_{DS}} \]

Substituting \( V_I \) into the \( I_{DS2} \) equation and simplifying gives \( I_{DS1} = I_{DS2} \).

2.3 The body effect does not change (a) because \( V_{sb} = 0 \). The body effect raises the threshold of the top transistor in (b) because \( V_{sb} > 0 \). This lowers the current through the series transistors, so \( I_{DS1} < I_{DS2} \).

2.4 \( C_{permicron} = \varepsilon L/t_{ox} = 3.9 \cdot 8.85e-14 F/cm \cdot 90e-7 cm / 16e-4 \mu m = 1.94 fF/\mu m. \)
2.5 The minimum size diffusion contact is $4 \times 5 \lambda$, or $1.2 \times 1.5 \mu m$. The area is $1.8 \mu m^2$ and perimeter is $5.4 \mu m$. Hence the total capacitance is

$$C_{db}(0V) = (1.8)(0.42) + (5.4)(0.33) = 2.54 fF$$

At a drain voltage of $VDD$, the capacitance reduces to

$$C_{db}(5V) = (1.8)(0.42)\left(1 + \frac{5}{0.98}\right)^{-0.44} + (5.4)(0.33)\left(1 + \frac{5}{0.98}\right)^{-0.12} = 1.78 fF$$

2.6 The new threshold voltage is found as

$$\phi_s = 2(0.026)\ln \frac{2 \cdot 10^{17}}{1.45 \cdot 10^{16}} = 0.85V$$

$$\gamma = \frac{100 \cdot 10^{-8}}{3.9 \cdot 8.85 \cdot 10^{-14}} \sqrt{2(1.6 \cdot 10^{-19})(11.7 \cdot 8.85 \cdot 10^{-14})(2 \cdot 10^{17})} = 0.75V^{1/2}$$

$$V_t = 0.7 + \gamma \left(\sqrt{\phi_s} + 4 - \sqrt{\phi_s}\right) = 1.66V$$

The threshold increases by 0.96 V.

2.7 No. Any number of transistors may be placed in series, although the delay increases with the square of the number of series transistors.

2.8 The threshold is increased by applying a negative body voltage so $V_{db} > 0$.

2.9 (a) $(1.2 - 0.3)2 / (1.2 - 0.4)2 = 1.26$ (26%)

(b) $\frac{e^{-0.3}}{1.4 \cdot 0.026} = 15.6$

(c) $nT/q = 34 mV$; $\frac{e^{-0.3}}{1.4 \cdot 0.034} = 8.2$ ; note, however, that the total leakage will normally be higher for both threshold voltages at high temperature.

2.10 The current through an ON transistor tends to decrease because the mobility goes down. The current through an OFF transistor increases because $V_t$ decreases. A chip will operate faster at low temperature.