1. (30 pts) Find the input referred $v_{os}$ for the differential amp shown if (a) $I_N = 0$, (b) $I_N = 1$

\[
\begin{align*}
 &\text{USE:} \quad (V)_{1,2} = (V)_{5,6} = \frac{10}{0.4} \\
 &\quad (V)_{3,4} = \frac{12.5}{0.4} \\
 &\quad I_N = 100 \text{mA/V}^2, \quad I_p = 0 \\
 &\quad I_N = 40 \text{mA/V}^2, \quad I_p = 0 \\
 &\quad A_{VTW} = 7.5 \text{mV-Vm} \\
 &\quad A_{VTp} = 12.5 \text{mV-Vm} \\
 &\quad A_{VT}(v) = A_{VT}(p) = 0 \\
\end{align*}
\]

$\phi_{in} = 200 \text{mA}$
2. (40 pts) The circuit shown below is used to bias the amplifier in Problem 1. (a) Find R to set \( I_{out} = 200 \mu A \) 
(b) Find \( I_{out} \) and the \( f_t \) of the amp at 25°C and 125°C 
If the resistor has a tempco of 1000 ppm and \( C_L = 3 \mu F \)

\[ R' = 100 \mu A/\mu V @ 25^\circ C \]
\[ R' = 66 \mu A/\mu V @ 125^\circ C \]
3. (30pts) The replica biasing circuit shown below is used to set $I_{out} = 100 \mu A$. Find the new value of $I_{out}$ if the on-chip resistor is low by 25%.

Use:

$\frac{V}{I} = \frac{12.5}{0.4}$

$\frac{V}{I} = \frac{20}{0.4}$

$\beta' = 100 \text{ mA/V}^2$

$\gamma = 2 \beta = 0$

$\gamma = 0$
Bonus (5pts): If the PMOS current mirror in the differential amp in problem #1 is changed to 2 PMOS current sources (see below), what effect will this have on the input offset voltage, $V_{os}$? Explain!