1-In the amplifier shown below, X denotes the W/L ratio of the transistors. The transistors \( M_4, M_{CMFB} \) and resistors \( R_{CM} \) are used to set the DC voltage of the output. Assuming all transistors are in saturation:

\[
\mu_n C_{ox} = 2 \mu_p C_{ox} \quad V_{thN} = |V_{thP}| = V_{th} 
\lambda = 0 
X = \frac{W}{L}
\]

For parts (a),(b), (c) and (d), your answer should be in terms of \( V_{eff} \) and \( V_{th} \) of \( M_1 \) and \( V_{cm} \) (input common-mode).

a) What is the drain-source current \( (I_{ds}) \) of \( M_{CMFB} \)? (20%)
b) What is the \( V_{out} \) (\( V_{out+} \) and \( V_{out-} \)) DC voltage? (30%)
c) What is the \textbf{minimum} input common-mode voltage \( (V_{cm}) \) to guarantee all transistors remain in saturation (20%)
d) If \( M_{CMFB} \) is resized from \( 4X \) to \( 1X \), what would be the \( V_{DS} \) (drain-source voltage) of \( M_{1a} \) and \( M_{1b} \)? (15%)
e) Find the differential voltage gain \( \frac{V_{out+} - V_{out-}}{V_{in+} - V_{in-}} \) assuming all transistors are in saturation (15%)
2- In the following circuit, assuming all the transistors are in saturation, and transistors have no parasitic capacitance, and \( \lambda \neq 0 \) (each transistor has output resistance equal to \( r_o \))

(a) Find the poles at \( V_X \) and \( V_{out} \) (40%)
(b) Find the unity gain BW (\( \omega_{UGBW} \)) assuming \( \omega_X \) (pole at \( V_X \)) is the dominant pole and \( \omega_{out} \) (pole at \( V_{out} \)) is at much higher frequency than \( \omega_{UGBW} \). \( \omega_{out} \gg \omega_{UGBW} \) (30%)
(c) If \( \omega_{out} = \omega_X \), give an expression for the -3dB frequency of the system (30%)