1. (a) In Fig. 1(a), assume the opamp is ideal with output saturation voltages of $\pm V_L$. The diode has a constant voltage drop of V_D when conducting. If V_i is a sinusoidal input signal, plot the waveforms for V_i, V_x, and V_o. (10%)

   (b) In Fig. 1(b), the diode is replaced with a BJT, Q_1. Find an expression for V_o. Please clearly define the parameters used in your final expression. (20%)

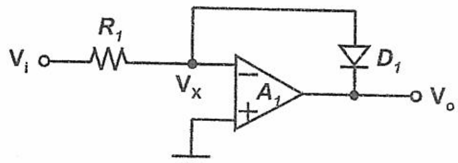

Fig. 1(a)

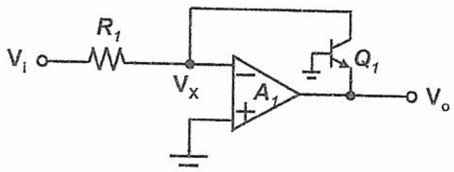

Fig. 1(b)

2. Fig. 2 is a capacitance multiplier circuit, which is used in creating a large effective capacitance with a smaller capacitor (C_1). Assume the circuit is properly biased.

   (a) Explain why this is a capacitance multiplier. Draw a simplified equivalent model to help your explanation. (10%)

   (b) Sketch the magnitude of the impedance Z_X looking into the circuit versus frequency. Please label key values (magnitude, frequency values) in the plot. (20%)

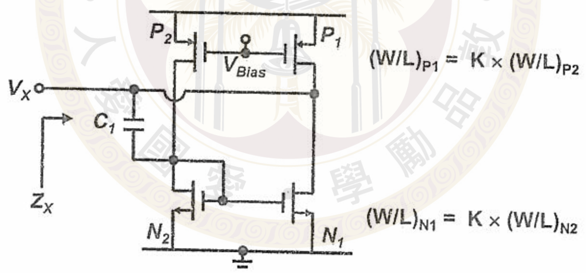

Fig. 2

3. Please apply the Barkhausen criterion to analyze the circuits shown in Fig. 3(a) and Fig. 3(b). Assume both circuits are properly biased.

   (a) In Fig. 3(a), two single-stage common-source (CS) amplifiers are connected in series and form a feedback loop. Assume each CS amplifier has only one pole dominated by C_L (ignore other parasitic effects). Can this circuit oscillate? You must provide detailed analysis. (15%)

   (b) For the circuit shown in Fig. 3(b), assuming the opamp is ideal and resistor R_1 is much larger than R_D. Repeat the same analysis and determine if this circuit can oscillate or not. (15%)

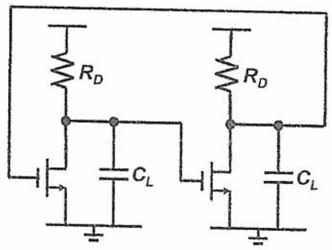

Fig. 3(a)

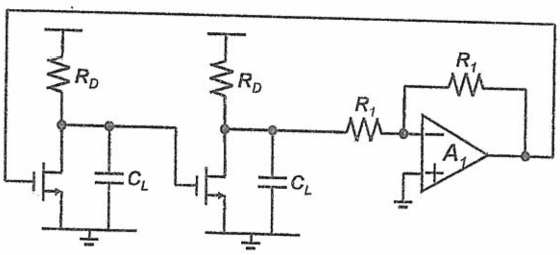

Fig. 3(b)

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4. For the transistors in Fig. 4, ignoring their body effect but including the channel-length modulation effect. Please derive an expression for the circuit gain $A \equiv V_{Out}/(V_1 - V_2)$. (10%)

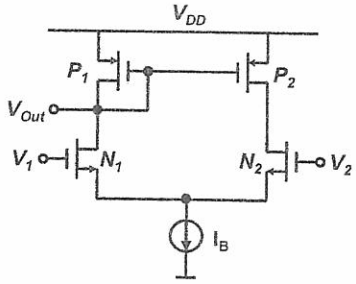

Fig. 4