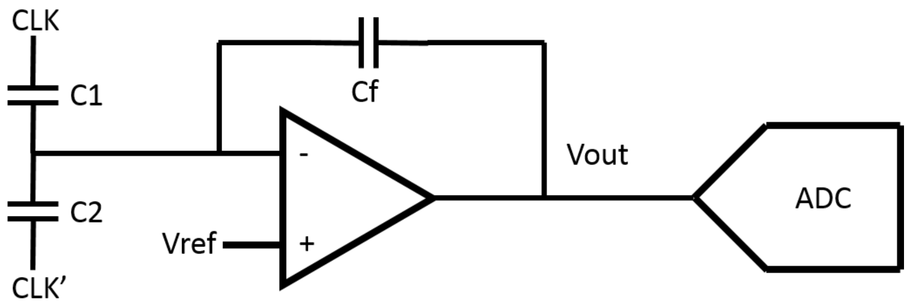
Capacitive MEMS Accelerometer Design Exercise.

You are tasked with designing a capacitive MEMS accelerometer for use in a sensor node. The accelerometer should be capable of measuring acceleration in the 1G-10G range.

1. Propose a mechanical implementation of such an accelerometer, taking into account different geometric approaches and their advantages/disadvantages.
2. You are targeting a displacement range of 10-100 nm for the given acceleration range. Considering the accelerometer has a known proof mass, calculate the spring constant k needed to satisfy the requested sensitivity S[nm/G]. Symbolic calculation is sufficient.
3. Calculate the change in capacitance dC as a consequence of the maximum targeted electrode displacement (100nm).

   Assume that you have 500 capacitor pairs, $\varepsilon = 8.85e - 12\ {}^{F}/_{m}$, Electrode overlap area $A = 100\mu m^2$ and the distance between electrodes in the absence of acceleration $d_0 = 1\mu m$.
4. Evaluate the linearity of the dC/dx curve in the given displacement range.
5. Assume that dC varies linearly with dx such that if dx=10nm, dC = 9fF, and if dx=100nm, then dC=90fF. We connect the accelerometer to a charge sensitive amplifier and an ADC, according to the following simplified schematic:



The relationship between the amplifier's output and the difference between the input capacitances (in this case, the accelerometer itself) is given by:

$$V_{OUT} = \frac{C_1 - C_2}{C_f} \cdot V_{ref}$$

What ADC resolution (in bits) would you need in order to measure down to 100mG accuracy?

Assume that Cf=90fF and the ADC can measure positive and negative voltages centered around Vref=1V, with a full scale voltage V_{FS} of 2V.