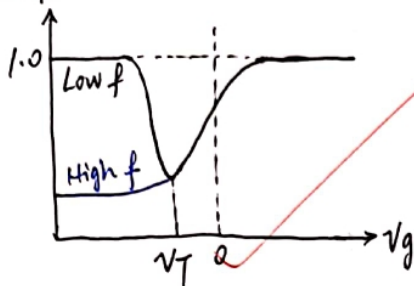


Name:

Student ID:

1. (a) Draw the C-V curves of a MOS capacitor with n-type Si as the substrate, at low frequency and high frequency, respectively. Explain why they are different.

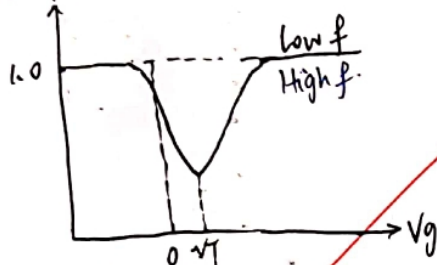
(b) Draw the C-V curve of a MOSFET at low frequency and high frequency and explain.

(a) C/C_0 

Because the source of the holes comes from:

1. diffusion of minority carrier holes from the n-type substrate across the space charge region.
2. Thermal generation of electron-hole pairs within the space charge region.

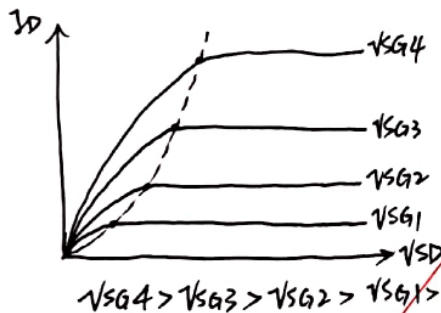
~~Both of them are not very efficient, which will affect the charging and discharging of the capacitor at high frequency.~~
At high-frequency, electron generation will be frozen out. Without inversion electrons, the capacitance will remain low.

(b) C/C_0 

(n-channel MOSFET)

Because electrons in the channel come from source and drain electrons. At high frequency, these electrons can move fast enough to respond to the gate electrode frequency. Therefore, the curve is the same for high and low frequency.

2. Draw the I_D - V_{SD} relationship for a p-type MOSFET at different gate voltages, assuming the source is grounded. Explain why there is the saturation region, and how the saturation point changes with different gate voltages.



When $V_{SD} > V_{SG} - |V_T|$, any increase in V_{SD} will reduce the amount of inversion charge due to the increase of the "pinch-off" region, but will also increase the charge velocity. The two effects balance each other and results in saturation.

Since $V_{SD(sat)} = V_{SG} - |V_T|$, the saturation point will increase as V_{SG} increases.

