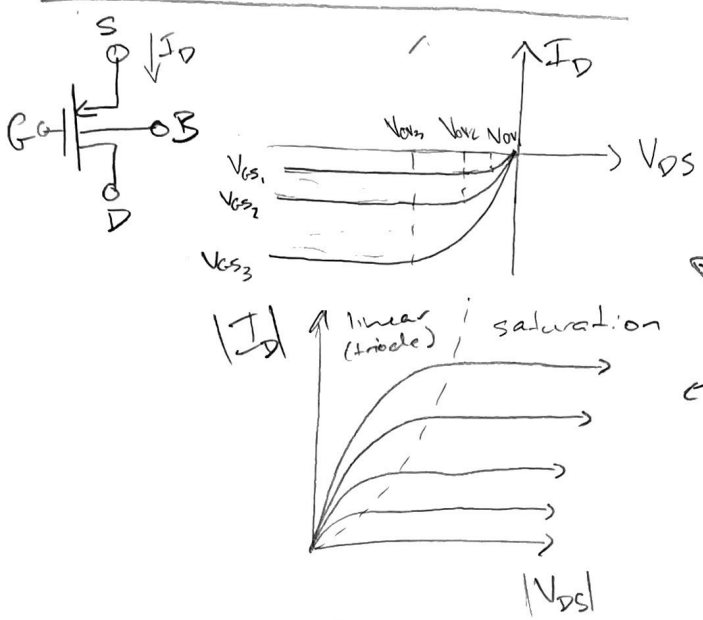
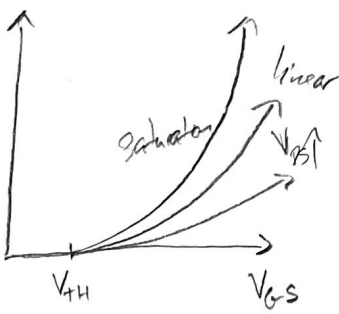
# ESE 3190 Lab 3: PMOS

$V_{ov} = V_{GS} - V_{TH}$










*although the polarities are opposite that of nMOS, people usually graph the PMOS IV characteristics the same as nMOS using absolute value

## PMOS equations:

triode region: $|V_{DS}| < |V_{GS} - V_{TH}|$

$$i_D = k_p' \frac{W}{L}\left[(V_{GS} - V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2\right]$$

saturation region: $|V_{DS}| \geq |V_{GS} - V_{TH}|$

$$i_D = \frac{1}{2} k_p' \frac{W}{L}(V_{GS} - V_{TH})^2$$

→ taking into account channel width modulation: $i_D = \frac{1}{2} k_p' \frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$

## Pre-Lab:

2.1


$V_{TH} = -0.73V$

$k_p' \frac{W}{L} = -2.9 \frac{mA}{V^2}$

a) $V_{DS} = -V_S$

$V_{GS} - V_{TH} = -V_S + 0.73V$

$|V_{DS}| \geq |V_{GS} - V_{TH}|$ → saturation region

b) $V_S = 0V$: $i_D = 0$ since $V_{GS} = 0 > V_{TH}$

$V_S = 1V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-1V + 0.73V)^2 = -0.100mA$

$V_S = 2V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-2V + 0.73V)^2 = -2.34mA$

$V_S = 3V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-3V + 0.73V)^2 = -7.47mA$

$V_S = 4V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-4V + 0.73V)^2 = -15.5mA$

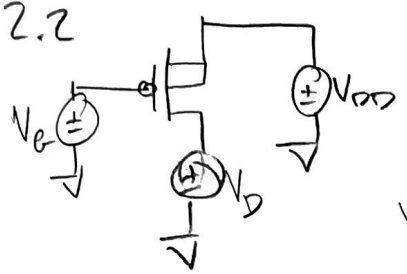
$V_S = 5V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-5V + 0.73V)^2 = -26.44mA$

$V_S = 6V$: $i_D = -\frac{2.9}{2}\frac{mA}{V^2}(-6V + 0.73V)^2$

$\Rightarrow i_D = -40.3mA$

*plot on separate page

2.2




$V_{DD} = 6V$

$V_D = 5.8V$

$V_{DS} = -0.2V$

$$r_{DS} = \frac{1}{k_p' \frac{W}{L}(V_{GS} - V_{TH})}$$

a)

| $V_G$ (V) | $r_{DS}$ (Ω) |
|---|---|
| 0 | 65.43 |
| 1 | 80.76 |
| 2 | 105.45 |
| 3 | 151.91 |
| 4 | 271.52 |

$$r_{DS,0} = \frac{1}{-2.9\frac{mA}{V^2}((0-6)V + 0.73V)} = 65.43\,\Omega$$

$$r_{DS,1} = \left(-2.9\frac{mA}{V^2}[(1-6)V + 0.73V]\right)^{-1} = 80.76\,\Omega$$

$$r_{DS,2} = \left[-2.9\frac{mA}{V^2}((2-6)V + 0.73V)\right]^{-1} = 105.45\,\Omega$$

$$r_{DS,3} = \left[-2.9\frac{mA}{V^2}((3-6)V + 0.73V)\right]^{-1} = 151.91\,\Omega$$

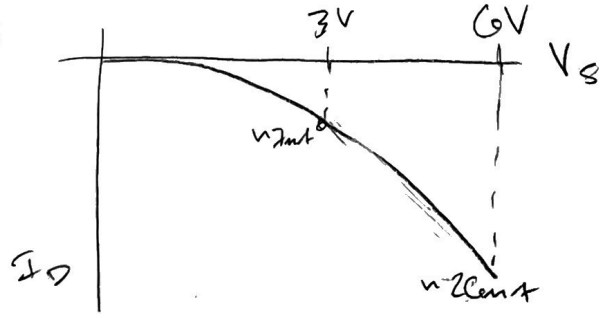
$$r_{DS,4} = \left[-2.9\frac{mA}{V^2}((4-6)V + 0.73V)\right]^{-1} = 271.52\,\Omega$$

b) *plot on separate page

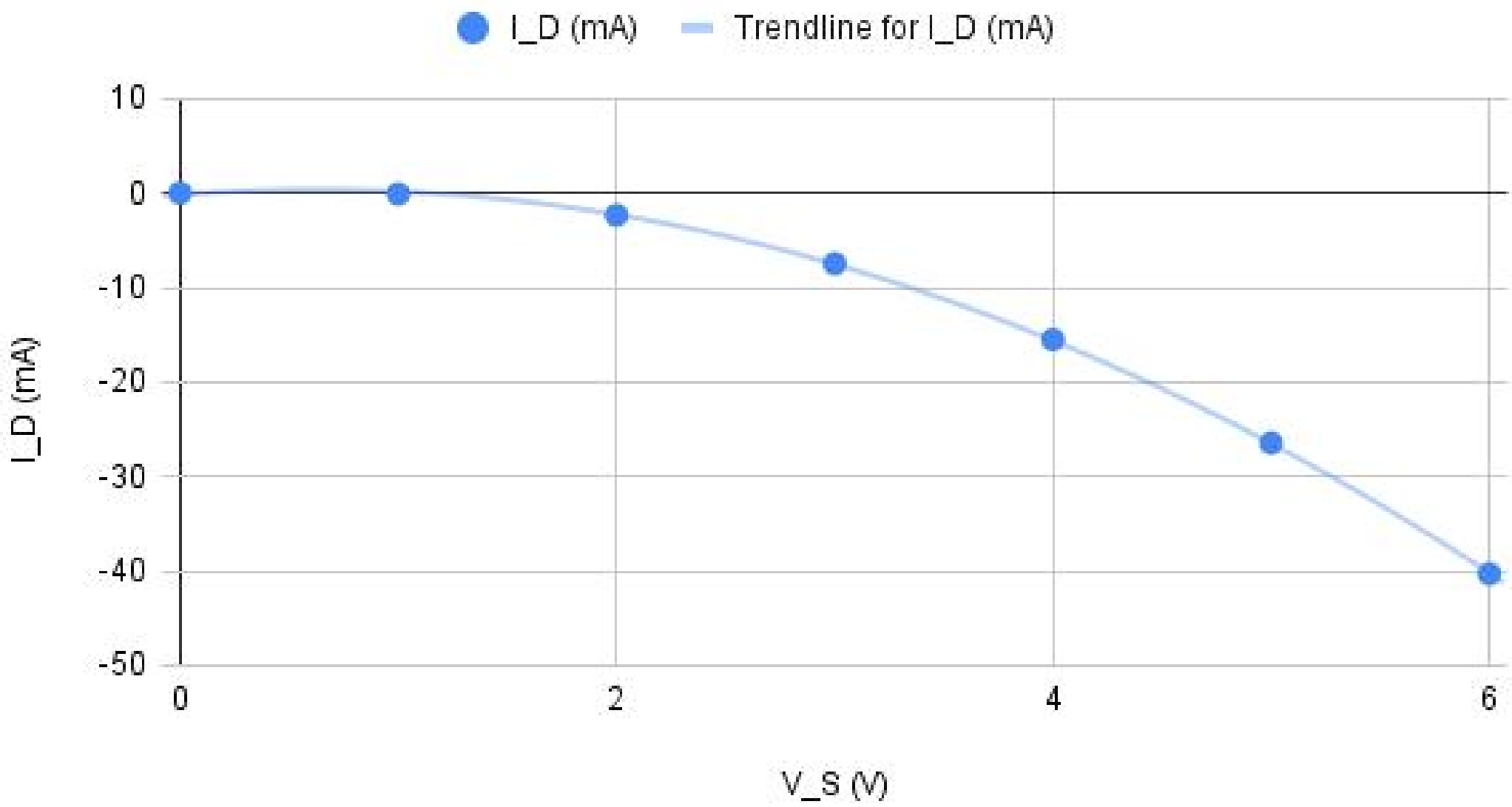
3.14 $V = iR \rightarrow R = \frac{V}{i}$

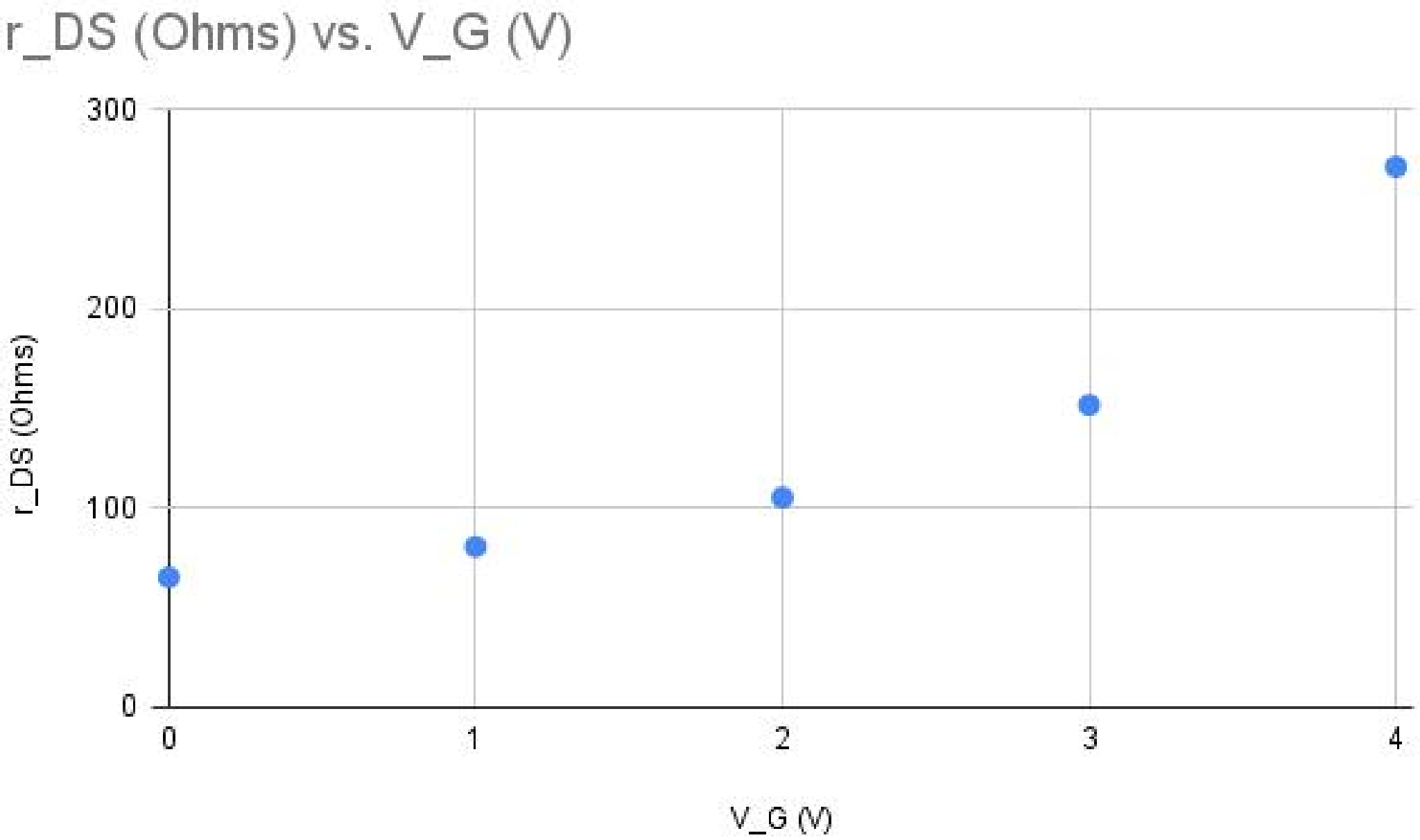
$$\frac{\Delta I}{\Delta V} = -\frac{19\,mA}{3V} = -6.3\cdot10^{-3}\,\frac{A}{V} \rightarrow R_{eq} = (6.33\cdot10^{-3})^{-1} = 157.89\,\Omega$$

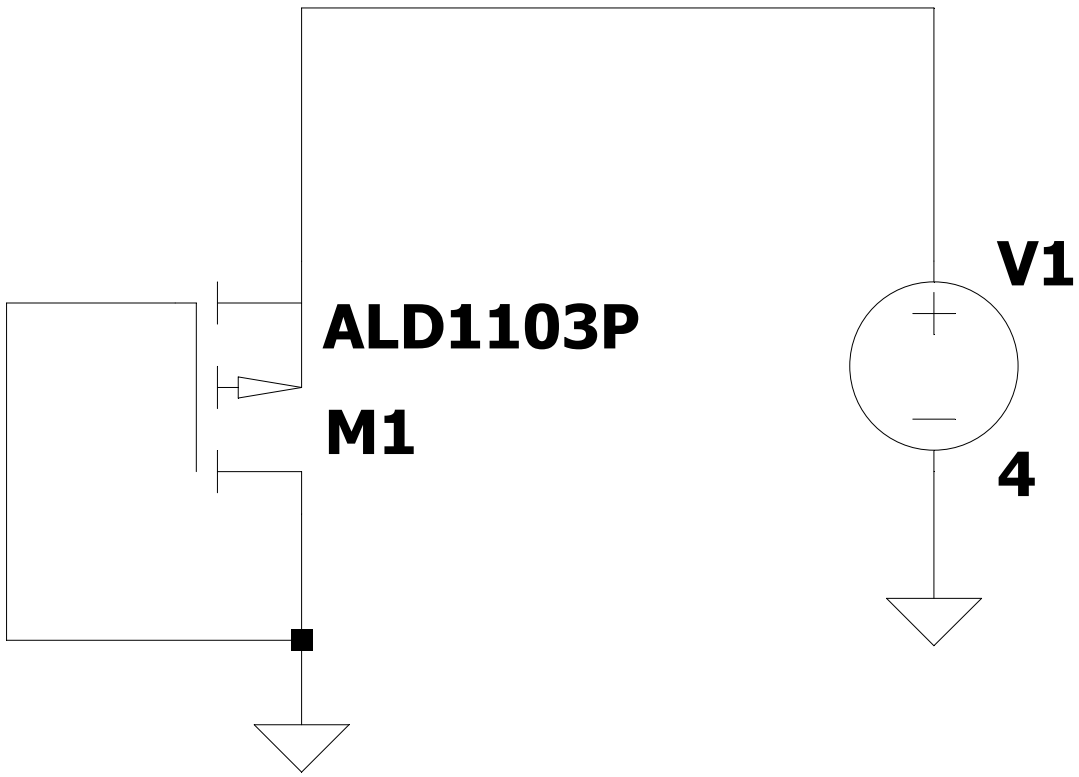
3.15

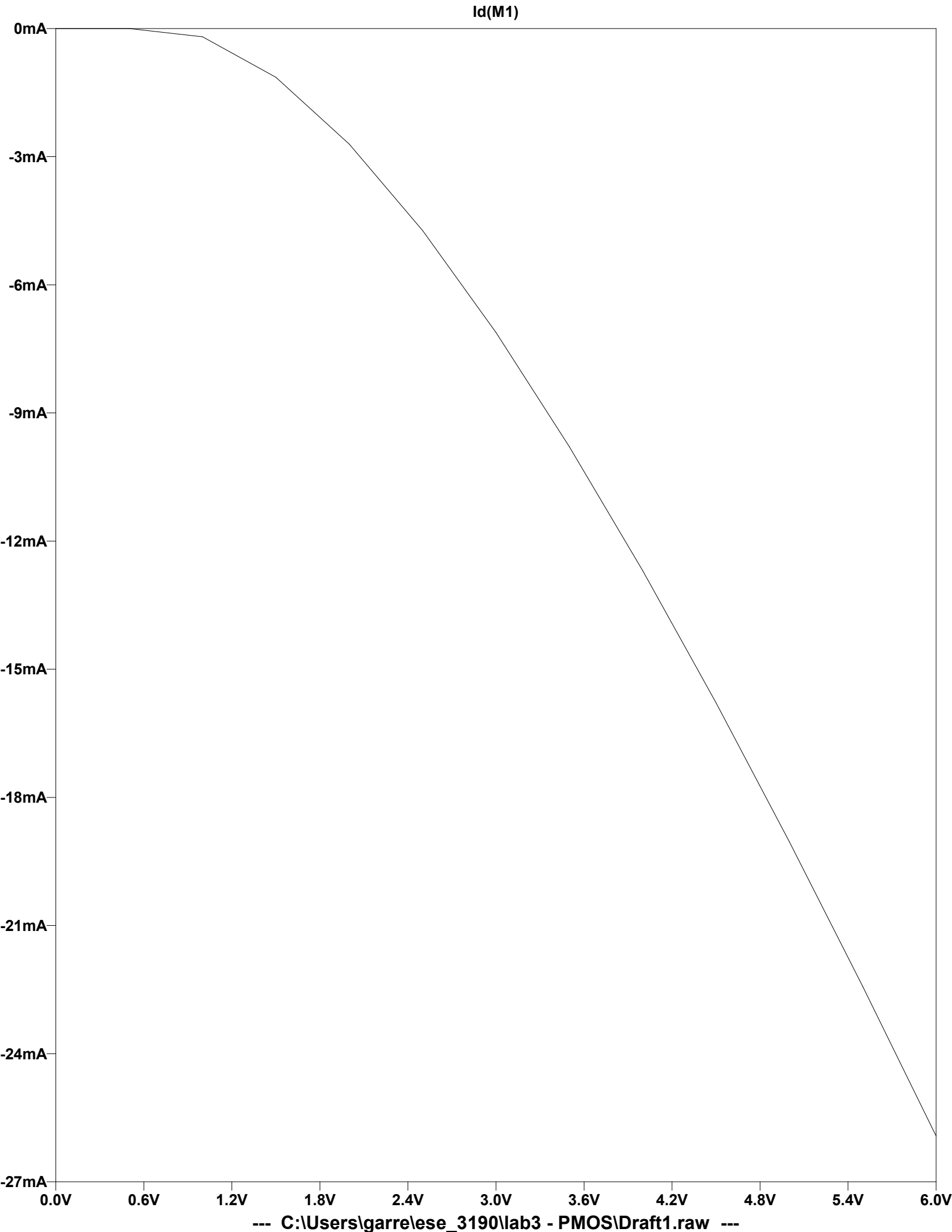



$i = g_m V_{GS}$


I_D (mA) vs. V_S (V)
I_D (mA)
Trendline for I_D (mA)
10
0
-10
-20
-30
-40
-50
I_D (mA)
0
2
4
6
V_S (V)


r_DS (Ohms) vs. V_G (V)
300
200
100
0
r_DS (Ohms)
0
1
2
3
4
V_G (V)


ALD1103P
M1
V1
4


Id(M1)
0mA
-3mA
-6mA
-9mA
-12mA
-15mA
-18mA
-21mA
-24mA
-27mA
0.0V
0.6V
1.2V
1.8V
2.4V
3.0V
3.6V
4.2V
4.8V
5.4V
6.0V
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