1) An NMOS transistor has parameters $W = 10 \, \mu m$, $L = 0.25 \, \mu m$, $k' = 200 \, \mu A/V^2$, $\lambda = 0.01 \, V^{-1}$, $V_{T0} = 0.5 \, V$, $\phi_f = 0.3 \, V$ and $\gamma = 0.5 \, V^{1/2}$.

   a) Sketch the $I_D-V_{DS}$ characteristics for $V_{DS}$ from 0 to 2.5 V and $V_{GS} = 1.5 \, V$, 2.5 V. Assume $V_{BS} = 0 \, V$.

   b) Sketch the $I_D-V_{GS}$ characteristics for $V_{GS}$ from 0 to 2.5 V and $V_{DS} = 1 \, V$ and 2.5 V. Assume $V_{BS} = -1 \, V$.

2) Using figure 1, estimate the model parameters $V_{T0}$, $\gamma$, $k'$ and $\lambda$. Assume $W/L = 100$ and $\phi_f = 0.3 \, V$. Explain your method.

**Figure 1**

```plaintext
0 0.2 0.4 0.6 0.8 1 1.2
VDS (V)

0 2 4 6 8
ID (mA)

VGS = 1 V, VBS = 0 V
VGS = 1 V, VBS = -0.5 V
VGS = 0.8 V, VBS = 0 V
VGS = 0.8 V, VBS = -0.5 V
VGS = 0.6 V, VBS = 0 V
VGS = 0.6 V, VBS = -0.5 V
```