Extraction of DC Characteristics of BJT and MOSFET
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19/11/2020

Quiz Question) Answer for the question can be seen below.

$$ID = 150130043 \quad R = 85k$$

1) $5V - I_B \cdot 85 - V_{BE} - 1 \cdot I_E = 0 \quad I_E = 100 I_B$

$5V - 85 I_B - 1V - 100 I_B = 0$

$4V = 185 I_B$

$I_B = 0,0216$

2) $vcc - 3k \cdot I_c - V_{CE} - I_E \cdot 1k \quad I_c = 85 I_B = 2,1384$

$\qquad\qquad\qquad\qquad\qquad I_E = 100 I_B = 2,16$
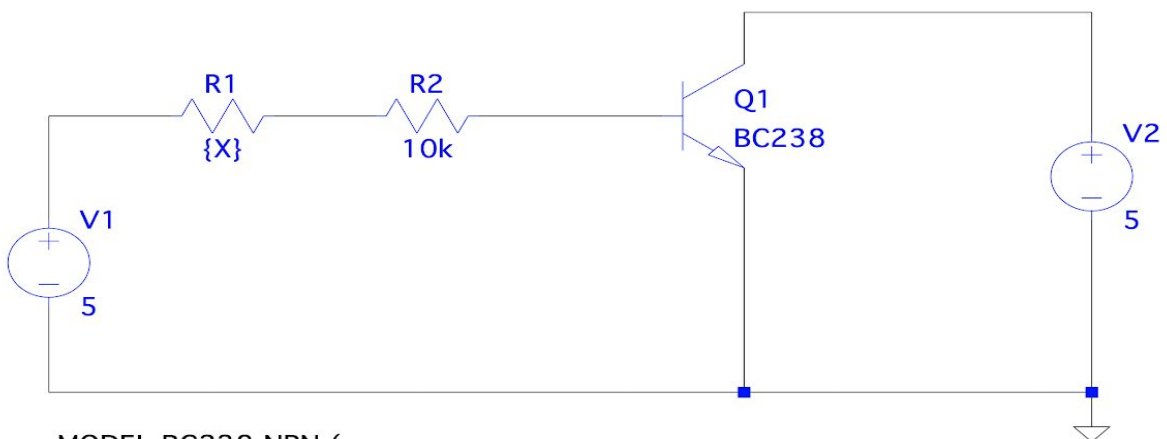
$10v - 6,4152 - 2,16 = V_{CE}$

$V_{CE} = 1,4248 V$

Part 2.1)
Pictures for the main circuit and the graph obtained to be used in the table calculations are shown.

.MODEL BC238 NPN (
+IS =1.8E-14 ISE=5.0E-14 NF =.9955 NE =1.46 BF =400
+BR =35.5 IKF=.14 IKR=.03 ISC=1.72E-13 NC =1.27 NR =1.005 RB =.56 RE =.6
+RC =.25 VAF=80 VAR=12.5 CJE=13E-12 TF =.64E-9 CJC=4E-12 TR =50.72E-9
+VJC=.54 MJC=.33)
.step param X .1k .1Meg .1k
.op

V(n001)   V(n004)   V(n003)   Ib(Q1)   Ie(Q1)   Ic(Q1)

Talking:
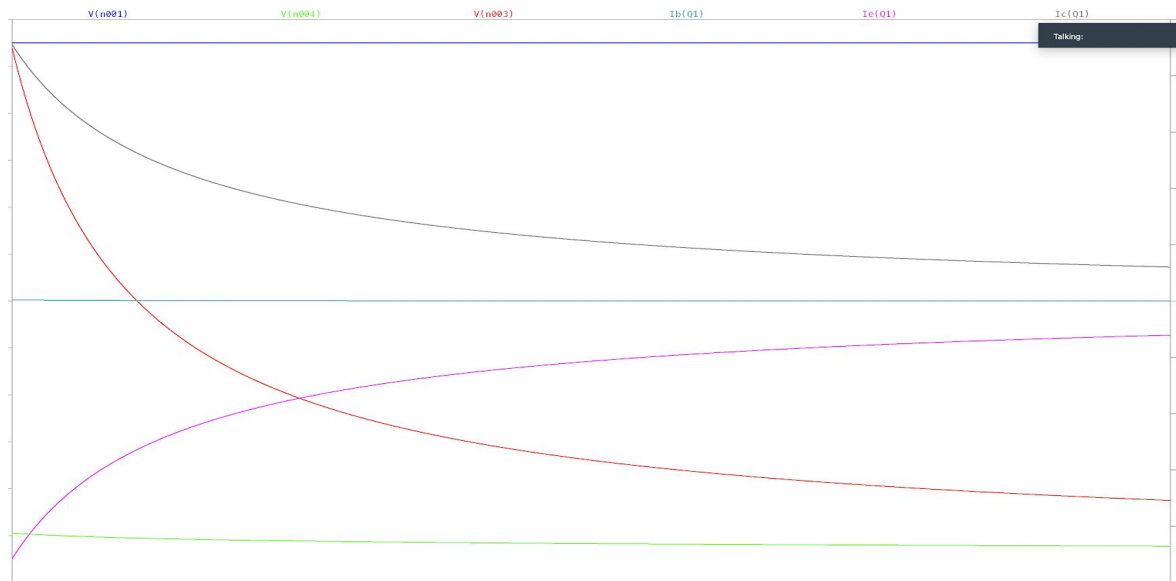
These are the table results we get by reading the graph and making the necessary calculations.

Table 1: Measurement results of experiment 2.1

R_1	V_{BE}	I_C	V_{R2}	I_B	β
10k	0.783V	54,95 milliampere	2,05V	208 nanoampere	265,18
20k	0.763V	39,64 milliampere	1,37V	138 nanoampere	288,24
30k	0.749V	30,88 milliampere	1,08V	106 nanoampere	292,32
40k	0.738V	23,99 milliampere	0,89V	82 nanoampere	293,56
50k	0.732V	21,48 milliampere	0,7V	65 nanoampere	331,46
60k	0.726V	18,28 milliampere	0,63V	58 nanoampere	316,17
70k	0.72V	17,78 milliampere	0,55V	53 nanoampere	336,47
80k	0.716V	16,24 milliampere	0,49V	47 nanoampere	346,53
90k	0.712V	14,29 milliampere	0,45V	43 nanoampere	333,32
100k	0.711V	12,78 milliampere	0,39V	38 nanoampere	337,31
110k	0.710V	11,12 milliampere	0,38V	34 nanoampere	327,47

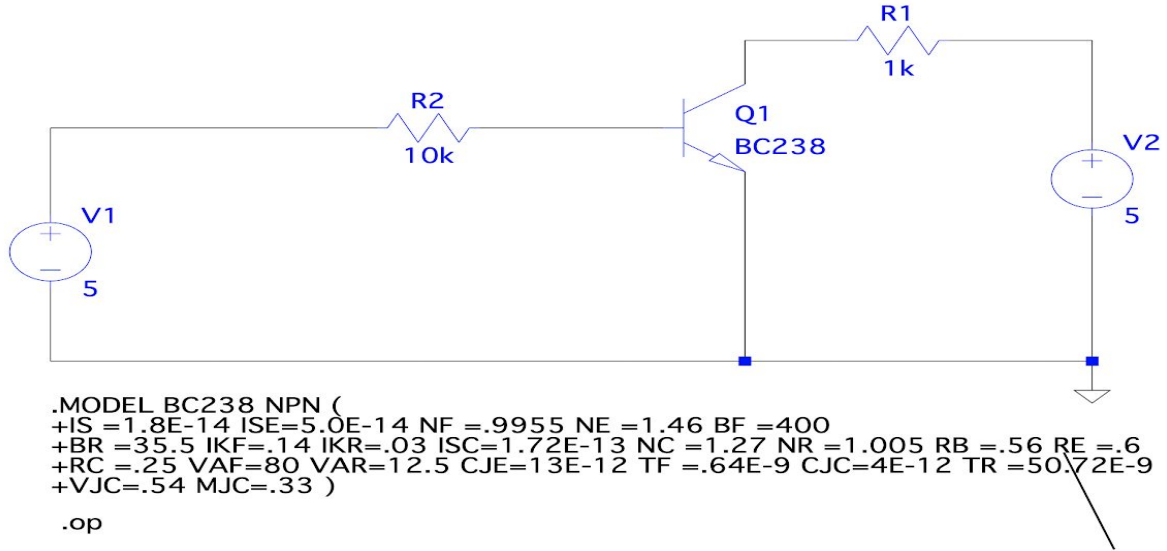Also the graphs needed using the table values are both included.

Vbe - Ic Graph)
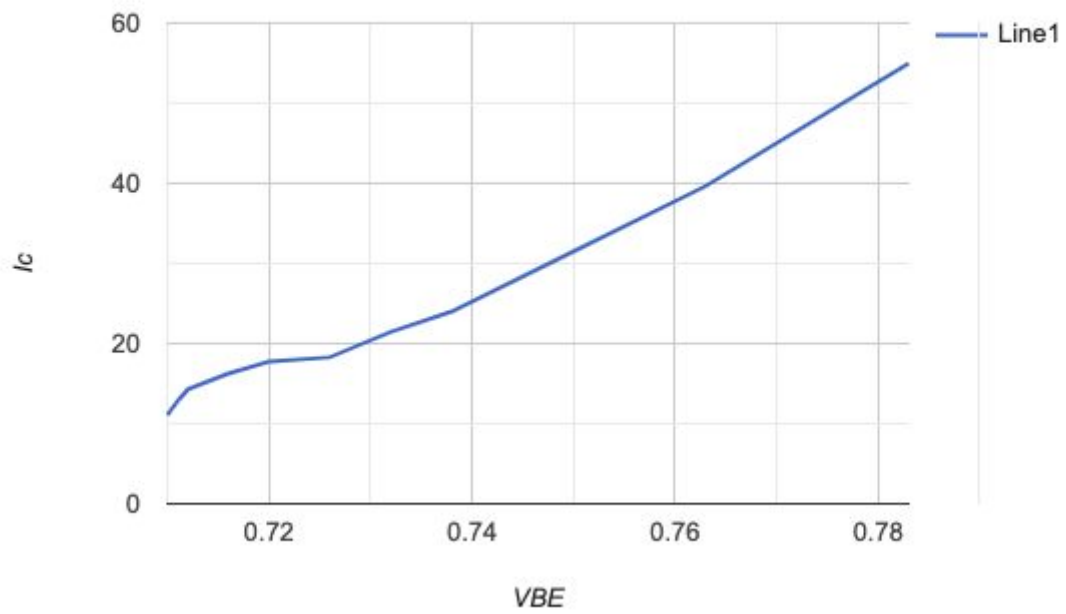
Ib - Ic Graph)
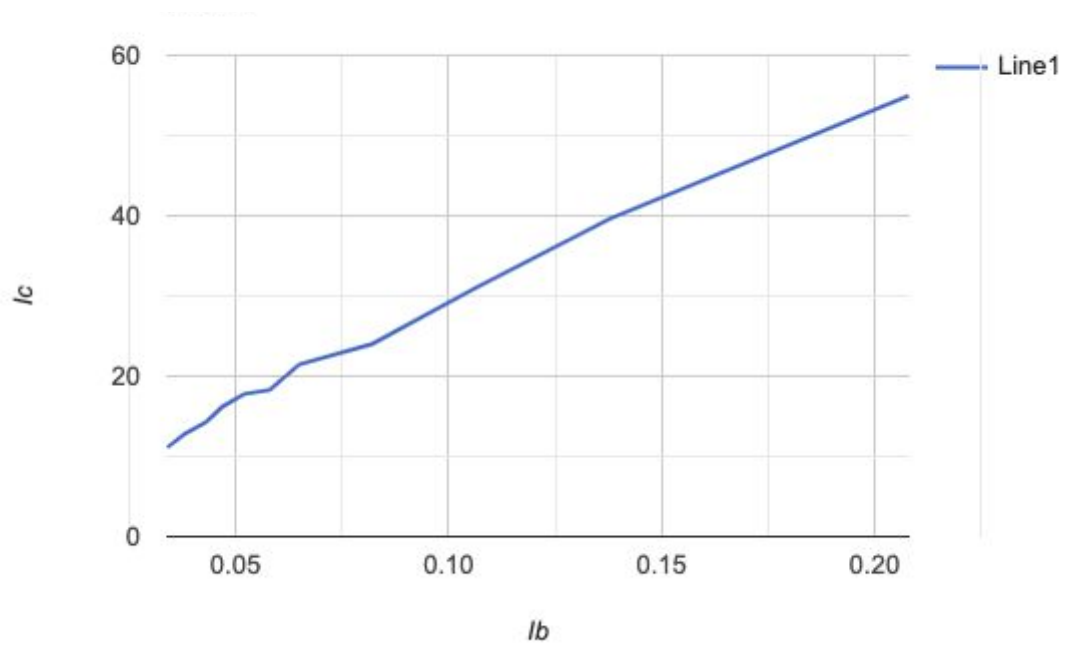
Part 2.2)

Pictures for the main circuit and the graph obtained to be used in the table calculations are shown.


```
.MODEL BC238 NPN (
+IS =1.8E-14 ISE=5.0E-14 NF =.9955 NE =1.46 BF =400
+BR =35.5 IKF=.14 IKR=.03 ISC=1.72E-13 NC =1.27 NR =1.005 RB =.56 RE =.6
+RC =.25 VAF=80 VAR=12.5 CJE=13E-12 TF =.64E-9 CJC=4E-12 TR =50.72E-9
+VJC=.54 MJC=.33 )

.op
```


Also the table values calculated are shown. Resistor value of 60k from part 2.1 was chosen for forward active mode measurements.

Table 2: forward active, reverse active and saturation mode

|	V_{BE}	V_{CE}	I_B	I_C	β
İleri Yönde Çalışma (Forward active mode)	0.726V	5V	58 nanoampere	18,28 milliampere	315,17
Doyma (Saturation)	0,706V	0.01825V	0,435 milliampere	4,973 milliampere	12,43

Part 2.3)

Pictures for the main circuit and the graph obtained to be used in the table calculations are shown.
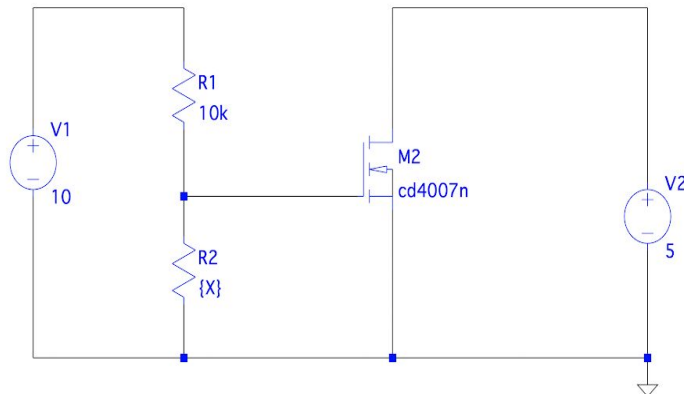
.MODEL cd4007n NMOS (
+LEVEL = 49 VERSION = 3.3 TNOM = 23
+TOX = 1e-07 XJ = 1e-06 NCH = 2e+16
+VTH0 = 1.14098 K1 = 2.12491 K2 = 0.2
+U0 = 0.0165798 UA = 1e-12 UB = 1.31485e-16
+UC = 3.45708e-09 VSAT = 189307 A0 = 2
+AGS = 0.481611 B0 = 5.4717e-06 B1 = 0
+KETA = 0.034434 A1 = 0.0462264 A2 = 0.926415
+RDSW = 100 WR = 1 WINT = 1e-06
+LINT = 1e-07 VOFF = -0.0394991 NFACTOR = 0.320755
+CIT = 0 CDSC = 0.00024 CDSCD = 0
+CDSCB = 0 ETA0 = 0 ETAB = 0
+PCLM = 0.001 PDIBLC1 = 0 PDIBLC2 = 0.0086
+PDIBLCB = 0 DROUT = 0.56 PVAG = 1.03774
+DELTA = 0.0915943 IS = 2.15472e-13 MOBMOD = 1
+CAPMOD = 2 CGDO = 2.3e-10 CGSO = 2.3e-10
+CGBO = 1.065e-10 CJ = 0.000344 PB = 0.95
+MJ = 0.5 CJSW = 2.07e-10 PBSW = 0.95
+MJSW = 0.5 NOFF = 1 ACDE = 1 +MOIN = 15)

.step param X .1k .10Meg .1k
.op
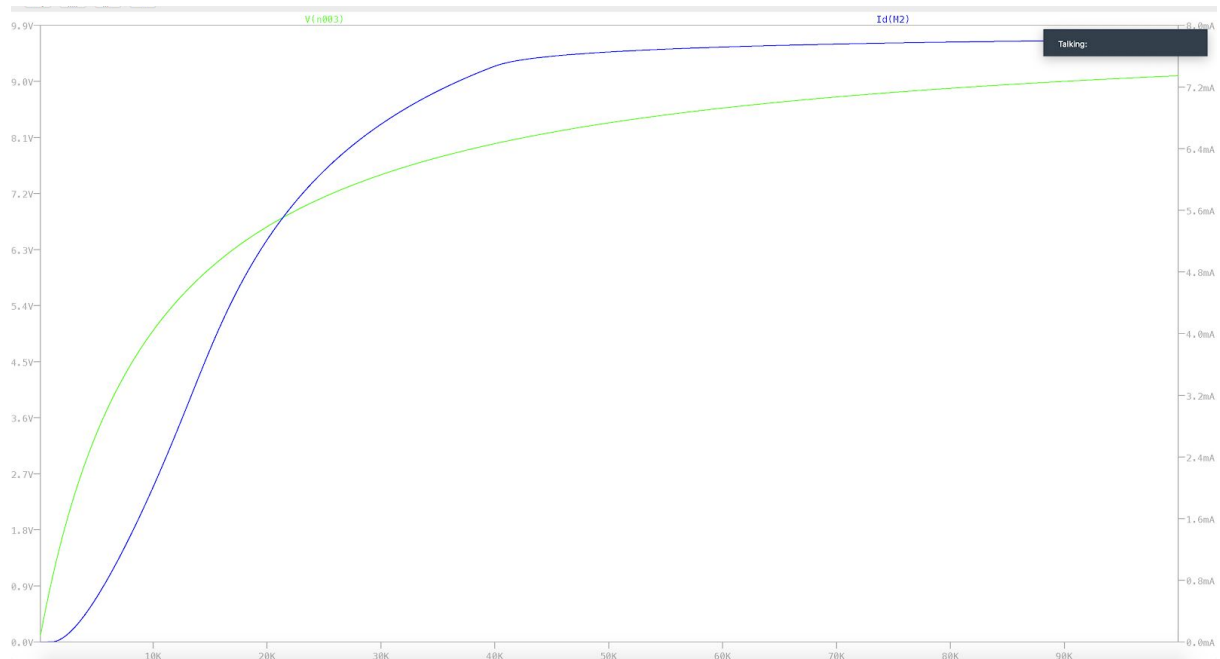
R is sweeped from 100k to 1k. Values start from 100k and go like 100k-90k-80k-...-1k.

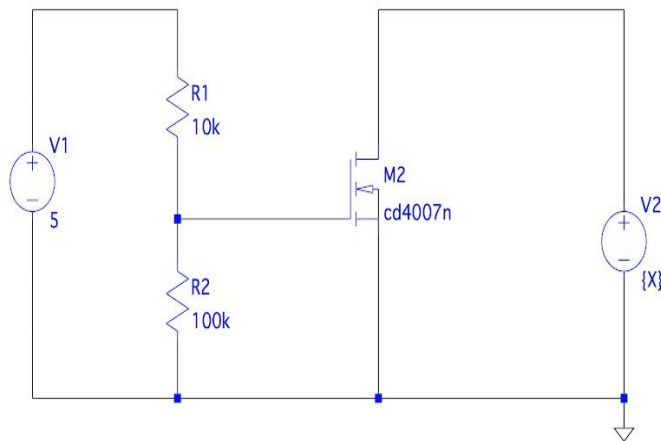| V$_{GS}$	I$_D$
9,017 V	7.809 milliampere
8,957 V	7,798 milliampere
8,8425 V	7,760 milliampere
8,688 V	7,747 milliampere
8,519 V	7,713 milliampere
8,203 V	7,623 milliampere
7,975 V	7,437 milliampere
7,628 V	6,685 milliampere
6,699 V	5,192 milliampere
4,919 V	1,978 milliampere
0,846 V	0,034 milliampere

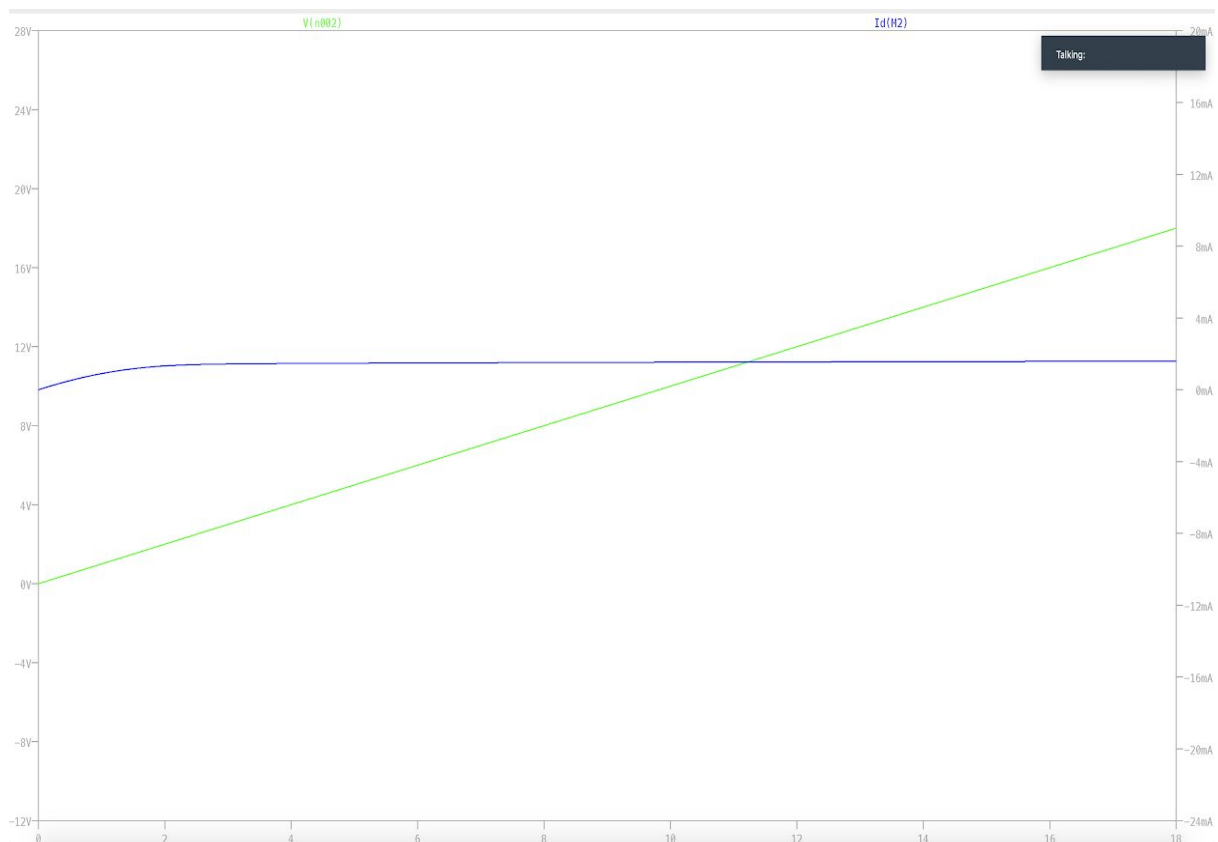Vgs-Id Graph)

Graph drawn using the values from the table
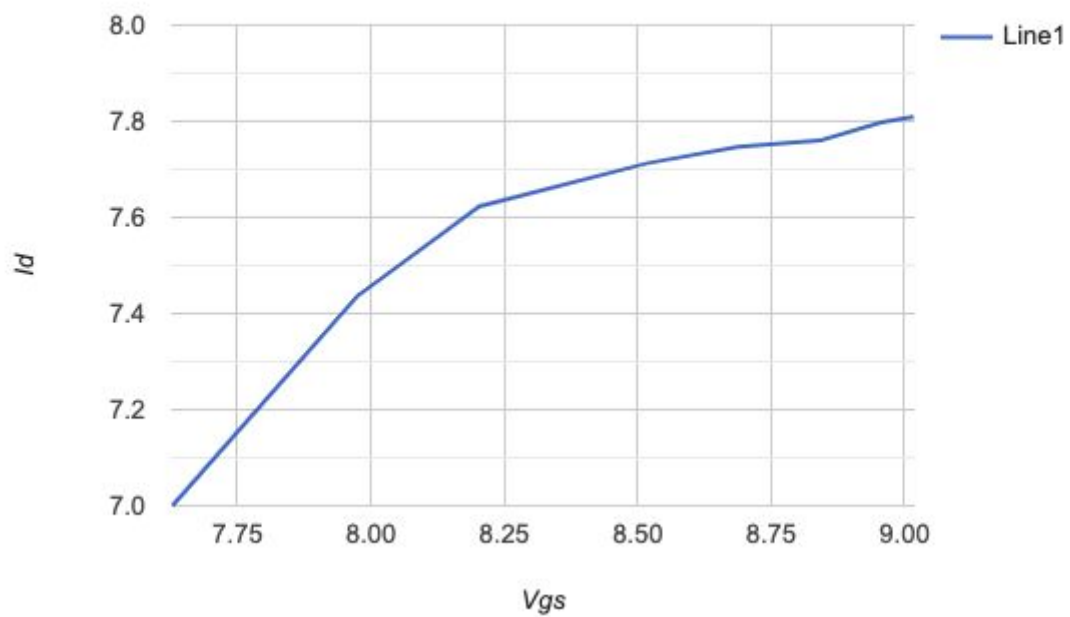
Part 2.4)

Pictures for the main circuit and the graph obtained to be used in the table calculations are shown.

.MODEL cd4007n NMOS (
+LEVEL = 49 VERSION = 3.3 TNOM = 23
+TOX = 1e-07 XJ = 1e-06 NCH = 2e+16
+VTHO = 1.14098 K1 = 2.12491 K2 = 0.2
+U0 = 0.0165798 UA = 1e-12 UB = 1.31485e-16
+UC = 3.45708e-09 VSAT = 189307 A0 = 2
+AGS = 0.481611 B0 = 5.4717e-06 B1 = 0
+KETA = 0.034434 A1 = 0.0462264 A2 = 0.926415
+RDSW = 100 WR = 1 WINT = 1e-06
+LINT = 1e-07 VOFF = -0.0394991 NFACTOR = 0.320755
+CIT = 0 CDSC = 0.00024 CDSCD = 0
+CDSCB = 0 ETA0 = 0 ETAB = 0
+PCLM = 0.001 PDIBLC1 = 0 PDIBLC2 = 0.0086
+PDIBLCB = 0 DROUT = 0.56 PVAG = 1.03774
+DELTA = 0.0915943 IS = 2.15472e-13 MOBMOD = 1
+CAPMOD = 2 CGDO = 2.3e-10 CGSO = 2.3e-10
+CGBO = 1.065e-10 CJ = 0.000344 PB = 0.95
+MJ = 0.5 CJSW = 2.07e-10 PBSW = 0.95
+MJSW = 0.5 NOFF = 1 ACDE = 1 +MOIN = 15)

.step param X .0 .1k .1
.op

V is sweeped from 0 to 10. Values start from 1 and go like 0-1-2-...-10

V$_{DS}$	I$_D$
0	-0,034 milliampere
0,88 V	0,71 milliampere
1,76 V	1,29 milliampere
2,88V	1,372 milliampere
3,69 V	1,381 milliampere
4,43 V	1,449 milliampere
5,84 V	1,491 milliampere
6,90 V	1,503 milliampere
7,51 V	1,514 milliampere
8,82 V	1,522 milliampere
9,82 V	1,523 milliampere

Vds-Id Graph)

Graph drawn using the values from the table

Part 2.5)

Pictures for the main circuit and the graph obtained to be used in the table calculations are shown. There is only one picture for one of the calculations on this part because the only things that change are the resistor and voltage values. Also since even the Id value is kept at 1mA in all calculations, I only put the graph of the first calculation as well.


```
.MODEL cd4007n NMOS (
+LEVEL = 49 VERSION = 3.3 TNOM = 23
+TOX = 1e-07 XJ = 1e-06 NCH = 2e+16
+VTHO = 1.14098 K1 = 2.12491 K2 = 0.2
+U0 = 0.0165798 UA = 1e-12 UB = 1.31485e-16
+UC = 3.45708e-09 VSAT = 189307 A0 = 2
+AGS = 0.481611 B0 = 5.4717e-06 B1 = 0
+KETA = 0.034434 A1 = 0.0462264 A2 = 0.926415
+RDSW = 100 WR = 1 WINT = 1e-06
+LINT = 1e-07 VOFF = -0.0394991 NFACTOR = 0.320755
+CIT = 0 CDSC = 0.00024 CDSCD = 0
+CDSCB = 0 ETA0 = 0 ETAB = 0
+PCLM = 0.001 PDIBLC1 = 0 PDIBLC2 = 0.0086
+PDIBLCB = 0 DROUT = 0.56 PVAG = 1.03774
+DELTA = 0.0915943 IS = 2.15472e-13 MOBMOD = 1
+CAPMOD = 2 CGDO = 2.3e-10 CGSO = 2.3e-10
+CGBO = 1.065e-10 CJ = 0.000344 PB = 0.95
+MJ = 0.5 CJSW = 2.07e-10 PBSW = 0.95
+MJSW = 0.5 NOFF = 1 ACDE = 1 +MOIN = 15 )

.op
```
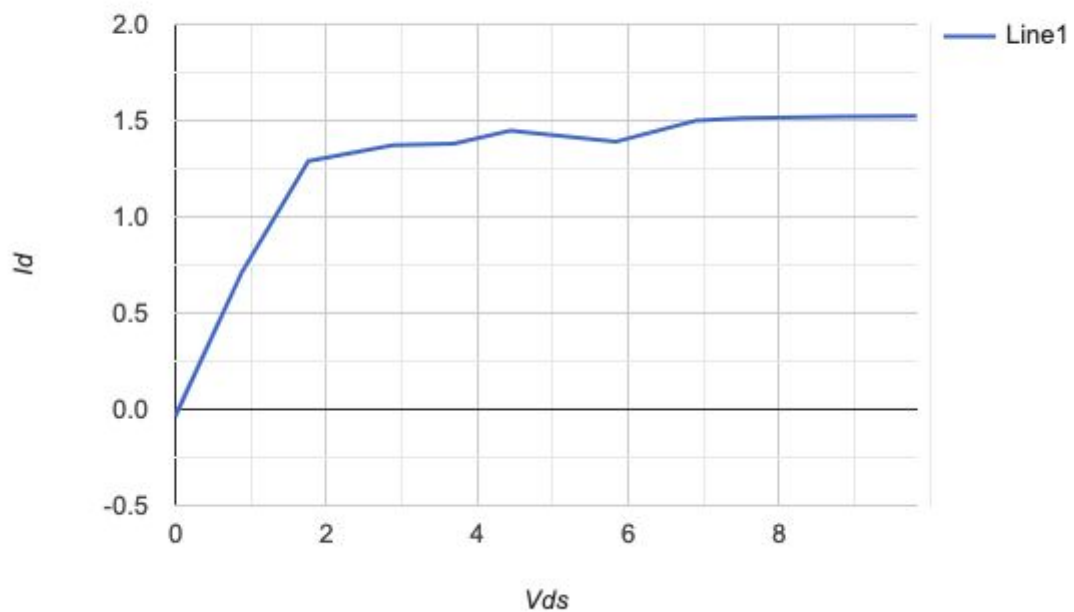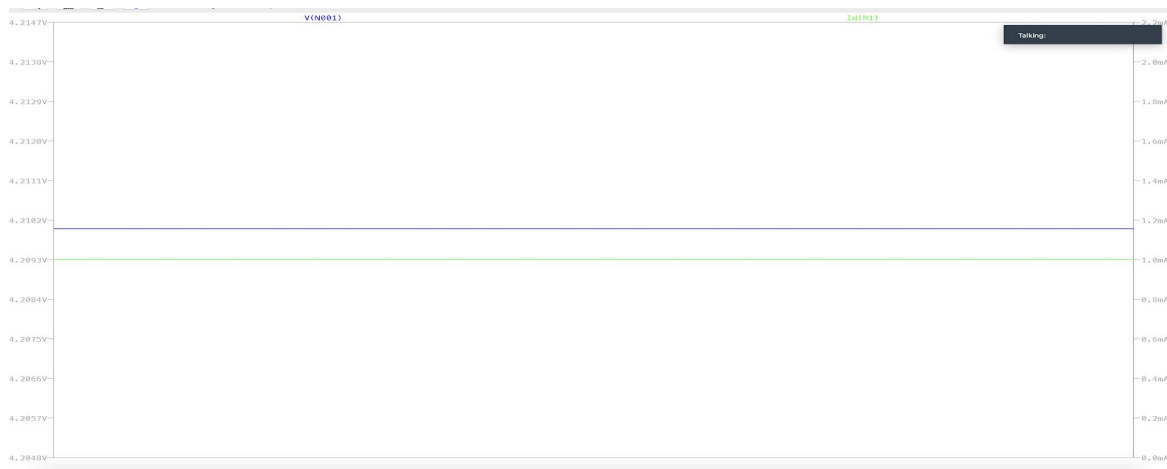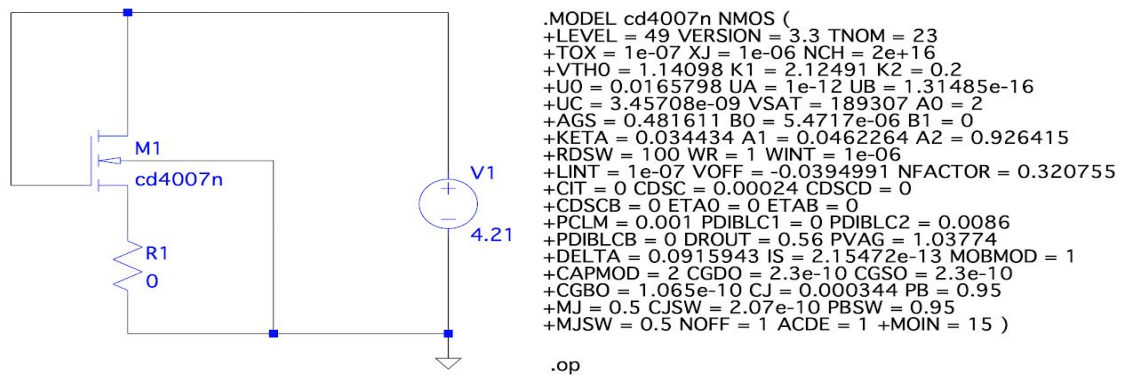

For each R value, the needed voltage for 1mA was found. These were R = 0, V = 4,21; R = 1, V = 6,32; R = 2,2, V = 8,53. Also the Vsb and Vgs values found for each resistor value is shown on the table consecutively depending on the order written above for each resistor value.

Table 5: $V_{SB} - V_{GS}$ values of Experiment 2.5

V_{SB}	V_{GS}
0 V	4,21 V
1 V	6,32 V
2.2 V	8,53 V