Experiment 1.1.

We will examine forward active mode of BJT transistor in this experiment. In case of $V_{BE} > 0$ and $V_{BC} < 0$, collector current will be;

$$I_C \cong I_S e^{V_{BE}/V_T}$$
$$I_C = \beta_F I_B$$

In order to obtain these 2 characteristics, set up the common emitter configuration in Figure 1. V_C will be 5V and R_3 will be short circuit. BJT transistor is BC238 and the model file of this transistor is at end of the Experiment 1.2. Fill the Table 1 by changing R_1 value. Sweep R_1 from 1k ohm to 1M ohm.

Different I_B and/or V_{BE} values can be obtained by changing R_1 resistance in the circuit. Write your measurement result to Table 1. Then draw the graphics in Figure 2 which shows us relationship between $I_C - V_{BE}$ and $I_C - I_B$. You can draw graphs by using Excel.

Note: You can change resistor value in LTspice so you can use resistor instead of potentiometer.

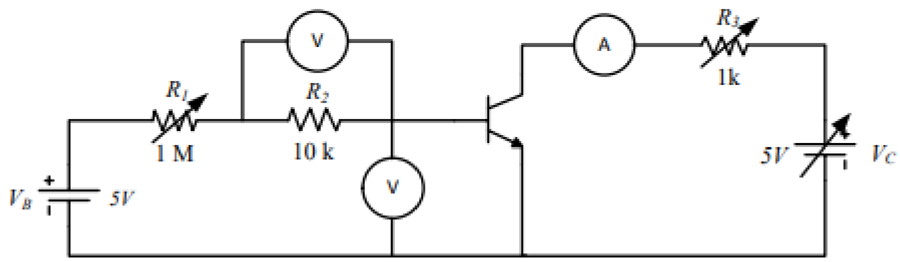

Figure 1: Common emitter configuration

Table 1: Measurement results of experiment 1.1

R_1	V_{BE}	I_C	V_{R2}	I_B	β

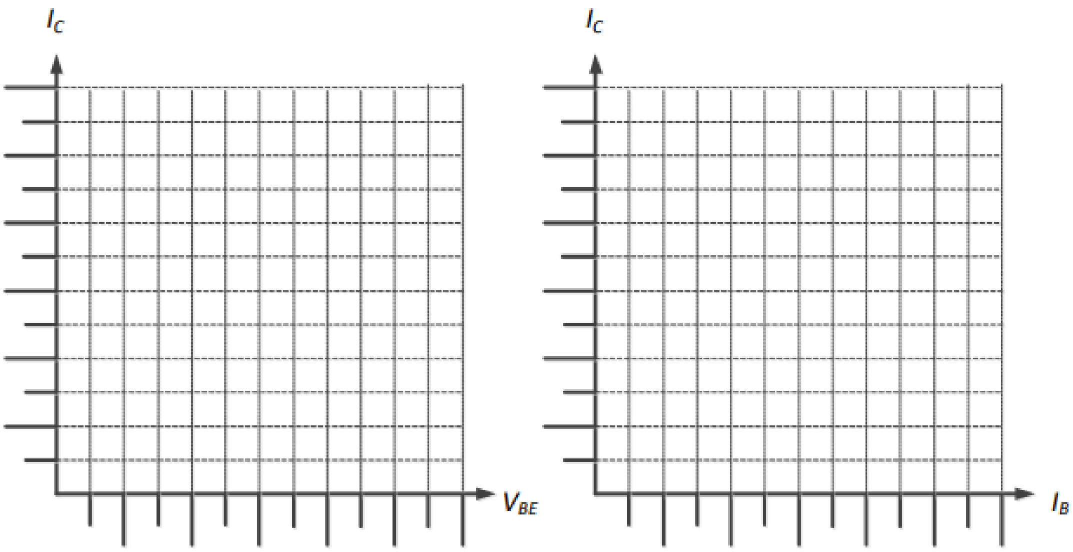

Figure 2: I_C – V_{BE} and I_C – I_B graphs

Experiment 1.2.

In this experiment we will examine the comparison between different operating modes of BJT transistor. For forward active mode you can choose an average value from R_1 values from Table 1 and write measurement results for this R_1 to Table 2.

For reverse active mode, switch connections between collector and emitter nodes and repeat measurements.

For saturation mode, make R_1 short circuit and connect R_3 as 1k ohm. Thus the transistor will enter saturation point ($V_{CB} < 0$). Write your results to Table 2.

Table 2: forward active, reverse active and saturation mode

	V_{BE}	V_{CE}	I_B	I_C	β
Forward active mode					
Reverse active mode					
Saturation					

The Model for BC238

```
.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 )
```

Experiment 1.3.

Setup the common source configuration in Figure 3. Choose V_G as 10V, and V_D as 5V. Simulate the circuit by decreasing R_2 value starting from 100kΩ. Fill in Table 3. Draw the $I_D - V_{GS}$ curve in Figure 4. Indicate the value of V_{th} in the $I_D - V_{GS}$ curve roughly.

Use the MOSFET model at the end of the Experiment 2.5. Set W =160u and L=2u.

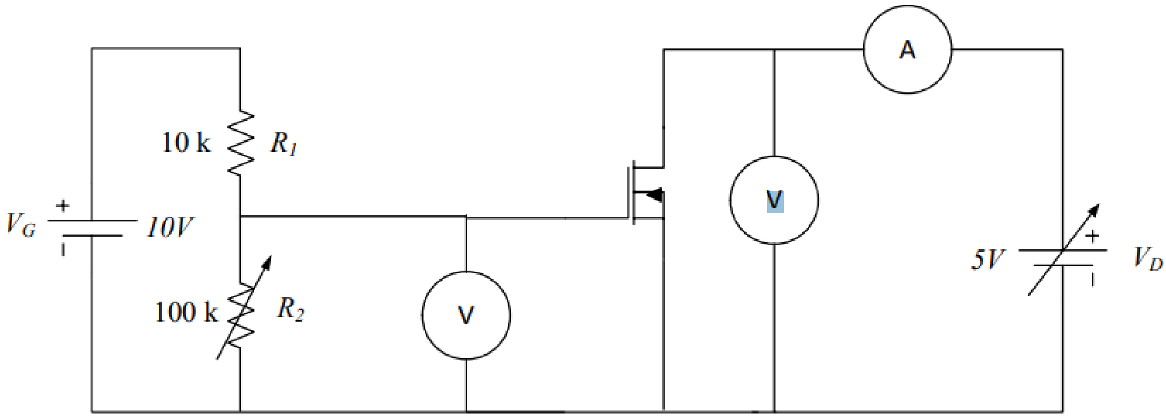

Figure 3:Common source configuration

Table 3:$V_{GS} - I_D$ values of Experiment 1.3

V_{GS}	I_D

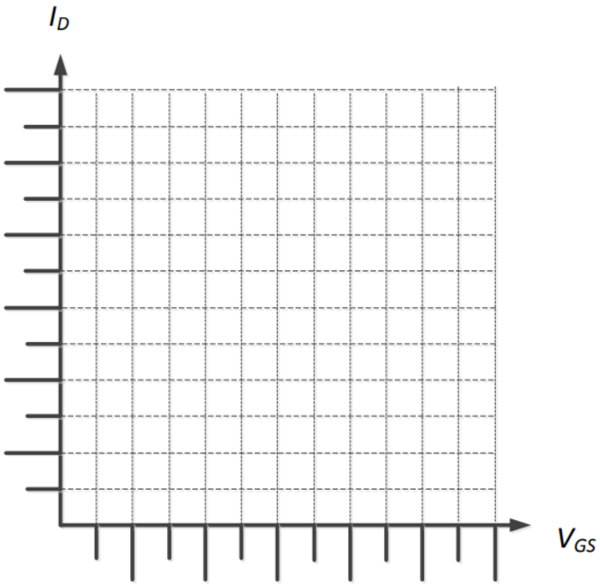

Figure 4: $I_D - V_{GS}$ curve

Experiment 1.4.

Choose V_G as 5V and R_2 as 100kΩ in Figure 3. Since R_2 is constant, V_{GS} remains constant. Sweep V_D value from 0V to 10V and draw $I_D - V_{DS}$ curve in Figure 5. Indicate different operation regions in $I_D - V_{GS}$ curve. Fill in Table 4.

Table 4:$V_{DS} - I_D$ values of Experiment 1.4

V_{DS}	I_D

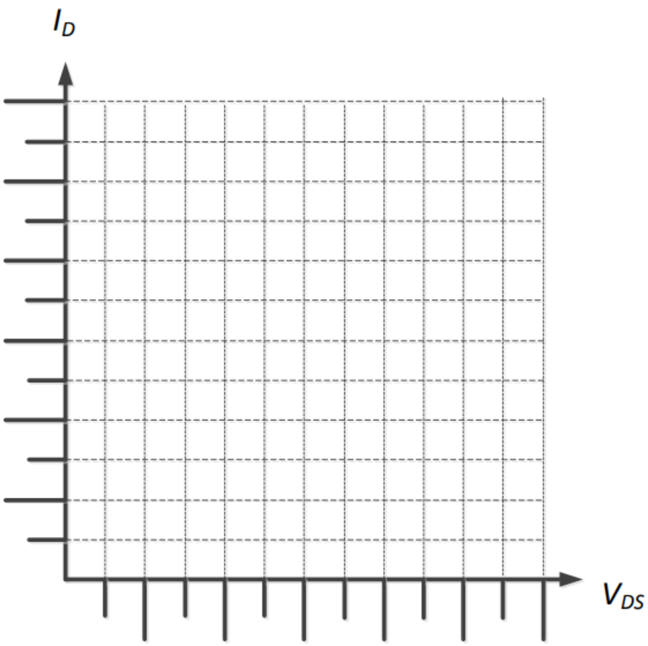

Figure 5: $I_D - V_{DS}$ curve

```
.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 )
```