Scilab Textbook Companion for Advance Semiconductor Devices by S. Sharma[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

Semiconductor Materials and Their Properties

Scilab code Exa 1.3 Volume density of Si

```
// Exa 1.3
clc;
clear;
close;
// Given data
a = 5.3;// in
a= a * 10^-10;// in m
N_A = 6.023*10^23;
At_Si = 28;// atomic weight of Si
n = 4;
m = At_Si/N_A;// in gm
m= m*10^-3;// in kg
V = a^3;// in m^3
Rho = (m*n)/V;// in kg/m^3
disp(Rho,"Density of silicon crystal in kg/m^3 is");

// Note: There is calculation error to find the
   value of density. So the answer in the book is
   wrong.
```

Scilab code Exa 1.4 Density of copper crystal

```
// Exa 1.4
clc;
clear;
close;
// Given data
n = 4;
r = 1.278;// in
a = (4*r)/(sqrt(2));// in
a = a * 10^-10;// in m
V = (a)^3;// in m^3
At_W = 63.5;// atomic weight
N_A = 6.023*10^23;
m = At_W /N_A;// in gm
m = m*10^-3;// in kg
Rho = (m*n)/V;// in kg/m^3
disp(Rho,"Density of the crystal in kg/m^3 is");


// Note: There is calculation error to find the
    value of density. So the answer in the book is
    wrong.
```

Scilab code Exa 1.5 Wavelength of X ray

```
// Exa 1.5
clc;
clear;
close;
// Given data
```

```
d = 2.82;// in
d = d * 10^-10;// in m
n = 1;
theta1 = 10;// in degree
lembda = 2*d*sind(theta1);// in m
lembda = lembda  * 10^10;// in
disp(lembda,"Wavaelength of X ray in    is");
```

Scilab code Exa 1.6 Spacing of automatic layer in the crystal

```
// Exa 1.6
clc;
clear;
close;
// Given data
lembda = 1.6;// in
theta = 14.2;// in degree
n = 1;
d = (n*lembda)/(2*sind(theta));// in
disp(d,"The spacing of atomic layer in crystal in is");

// Note: The unit of the answer in the book is wrong.
```

Scilab code Exa 1.7 Interplaner spacing

```
// Exa 1.7
clc;
clear;
close;
// Given data
n = 1;
```

```
theta1 = 30;// in degree
lembda = 1.78;// in
d = (n*lembda)/(2*sind(theta1));// in
disp(d,"The interplanner spacing in   is");
```

Scilab code Exa 1.8 Interplaner spacing

```
// Exa 1.8
clc;
clear;
close;
// Given data
lembda = 0.58;// in
n = 1;
theta1 = 6.45;// in degree
d = (n*lembda)/(2*sind(theta1));// in
disp(d,"Part (i) : At angle of 6.45  , Interplaner spacing of the crystal in   is ");
theta2 = 9.15;// in degree
d1 = (n*lembda)/(2*sind(theta2));// in
disp(d1,"Part(ii) : At angle of 9.15  , Interplaner spacing of the crystal in   is ");
theta3 = 13;// in degree
n2 = 1;
d2 = (n2*lembda)/(2*sind(theta3));// in
disp(d2,"Part(iii) : At angle of 13  , Interplaner spacing of the crystal in   is ");
// For
n=2;
d2 = (n*lembda)/(2*sind(theta3));// in
disp(d2,"Part (iv) : The interplaner spacing in   is : ")
disp(d1,"The interplaner spacing for some other set of reflecting in   is : ")
```

Scilab code Exa 1.9 Glacing angle

```
// Exa 1.9
clc;
clear;
close;
// Given data
a = 2.814;// in
l = 0;
h = 1;
k = 0;
//d= a/(sqrt(h^2+k^2+l^2)), So
d=a;// in
n = 2;
lembda = 0.710;// in
theta = asind(n*lembda/(2*d));
disp(theta,"The glancing angle for a cubic in degree
    is :");
```

Scilab code Exa 1.10 Wavelength of X ray

```
//Exa 1.10
clc;
clear;
close;
// Given data
a = 3.65;// in
a = 3.65*10^-10;// in m
h = 1;
k = 0;
l = 0;
d= a/(sqrt(h^2+k^2+l^2));// in m
```

```
n = 1;
theta = 60;// in degree
lembda = 2*d*sind(theta);// in m
lembda = lembda * 10^10;// in
disp(lembda,"Wavelength of X ray in      is");
```

Scilab code Exa 1.11 Glacing angle

```
// Exa 1.11
clc;
clear;
close;
// Given data
lembda = 1.54;// in
density = 9.024;// in gm/cc
n = 1;
MI = 100;
At_W = 63.54;// atomic weight
N_A = 6.023*10^23;
m = At_W/N_A;// in gm
a =(density*m)^(1/3);// in cm
h = 1;
k = 0;
l = 0;
d= a/(sqrt(h^2+k^2+l^2));
theta = asind( (lembda * 10^-8)/(2*d) );// in degree
disp(theta,"The glancing angle in degree is");
```

Scilab code Exa 1.12 Wavelength of X ray

```
// Exa 1.12
clc;
clear;
```

```
close;
// Given data
a = 3.615;// in
theta = 22;// in degree
n = 1;
h = 1;
k = h;
l = k;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
lembda = 2*d*sind(theta);// in
disp(lembda,"The wavelength of X ray in    is");
theta2 =asind( lembda/d );// in degree
theta2 = theta2 * 2;// in degree
disp(theta2,"To get the 2nd order spectrum the
   position of the detector in degree is");
```

Scilab code Exa 1.13 Lattice constant

```
// Exa 1.13
clc;
clear;
close;
// Given data
n = 1;
lembda = 1.54;// in
theta = 21.7;// in degree
d = lembda/(2*sind(theta));// in
h = 1;
k = h;
l = k;
a = d*sqrt(h^2+k^2+l^2);// in
disp(a,"Lattice constant in    is");
```

Scilab code Exa 1.14 Distance between d211 planes

```
// Exa 1.14
clc;
clear;
close;
// Given data
h = 2;
k = 1;
l = 1;
a = 4.8;// in
d_211 = a/(sqrt(h^2+k^2+l^2));// in
disp(d_211,"The distance between planes in    is");
```

Scilab code Exa 1.15 Density of copper

```
// Exa 1.15
clc;
clear;
close;
// Given data
r = 1.28;// in
a = (4*r)/(sqrt(2));// in
a = a * 10^-8;// in cm
n = 4;
M = 63.5;
N_A = 6.023*10^23;
Rho = (n*M)/( N_A*((a)^3) );// in gm/cc
disp(Rho,"Density in gm/cc is");
```

Scilab code Exa 1.16 Number of atom per unit cell

```
// Exa 1.16
```

```
clc;
clear;
close;
// Given data
M = 55.85;
a = 2.9;// in
a = a * 10^-8;// in cm
Rho = 7.87;// in gm/cc
N_A = 6.023*10^23;
n = (Rho*N_A*((a)^3))/M;// atom per unit
disp("A lattice having "+string(round(n))+" atom per
    unit cell is a BCC structure");
```

Scilab code Exa 1.17 Radius of element atom

```
// Exa 1.17
clc;
clear;
close;
// Given data
M = 60;// in gm/mole
Rho = 6.23;// in gm/cc
n = 4;
N_A = 6.023*10^23;
a = ((n*M)/(N_A * Rho))^(1/3);// in cm
r = (a*sqrt(2))/n;//radius of atom in cm
r = r * 10^8;// in
disp(r,"Radius of atom in    is");
```

Scilab code Exa 1.18 Packing factor

```
// Exa 1.18
clc;
```

```
clear;
close;
// Given data
Rho = 5.96;// in gm/cc
M = 50;
n = 2;
N_A = 6.023*10^23;
a =((n*M)/(Rho*N_A))^(1/3);// in cm
r = (a*sqrt(3))/4;// in cm
P_f = (2*(4/3)*%pi*((r)^3))/((a)^3);// packing
    factor
disp(P_f,"Packing factor is ");
```

Scilab code Exa 1.19 Number of unit cell

```
// Exa 1.19
clc;
clear;
close;
// Given data
M = 120;
n = 2;
N_A = 6.023*10^23;
m1 = M/N_A;//mass of 1 atom in gm
m2 = n*m1;//mass of unit cell in gm
disp(20/m2,"Number of unit cell in 20 gms of element
     is : ")
```

Scilab code Exa 1.20 Distance between K and F

```
// Exa 1.20
clc;
clear;
```

```
close;
// Given data
Rho = 2.48;// in gm/c.c
n = 4;
M = 58;
N_A = 6.023*10^23;
a = ( (n*M)/(Rho*N_A) )^(1/3);// in cm
a = a * 10^8;// in
r = (a*sqrt(2))/n;// in
r = 2*r;// in
disp(r,"The center to center distance between ions
    in    is");
```

Chapter 2

Carrier Transport in Semiconductor

Scilab code Exa 2.1 Energy gap

```
// Exa 2.1
clc;
clear;
close;
// Given data
lembda = 11000;// in
lembda = lembda * 10^-10;
h = 6.625*10^-34;
c = 3*10^8;
q = 1.6*10^-19;// in C
E_g = h*c/lembda;// in J
E_g= E_g/q;// in eV
disp(E_g,"The energy gap in Si in eV is");

// Note: The answer in the book is not correct
```

Scilab code Exa 2.2 Wavelength

```
// Exa 2.2
clc;
clear;
close;
// Given data
E_g = 0.75;// in eV
q=1.6*10^-19;// in C
E_g = E_g*q;// in J
h = 6.63*10^-34;// in J
c = 3*10^8;// in m/s
lembda = (h*c)/E_g;// in m
lembda = lembda * 10^10;// in
disp(lembda,"The wavelength in    is");
```

Scilab code Exa 2.3 Position of Fermi level

```
// Exa 2.3
clc;
clear;
close;
// Given data
del_E = 0.3;//value of E_C-E_F in eV
T1 = 330;// in K
T = 300;// in K
del_E1 = del_E*(T1/T);//value of E_C-E_F in eV
disp(del_E1,"The position of fermi level in eV is");
disp("Hence the Fermi level will be "+string(del_E1)
   +" eV below the conduction band")
```

Scilab code Exa 2.4 Probability

```
// Exa 2.4
clc;
clear;
close;
// Given data
K = 8.63*10^-5;
T = 300;// in K
N_C = 2.8*10^19;// in cm^-3
del_E = 0.25;
f_F = exp( (-del_E)/(K*T) );
disp(f_F,"The probability is : ");
n_o = N_C*exp( (-del_E)/(K*T) );// in cm^-3
disp(n_o,"The thermal equillibrium electron
    concentration in cm^-3 is");
```

Scilab code Exa 2.5 Thermal equilibrium hole concentration

```
// Exa 2.5
clc;
clear;
close;
// Given data
N_V = 1.04*10^19;// in cm^-3
T1 = 400;// in K
T2 = 300;// in K
del_E = 0.27;//value of E_F-E_V in eV
K = 0.0259;
N_V= N_V*(T1/T2)^(3/2);// in cm^-3
KT = K*(T1/T2);// in eV
p_o = N_V*exp( (-del_E)/(KT) );// in /cm^3
disp(p_o,"The hole concentration per cm^3 is");
```

Scilab code Exa 2.6 Mobility of electrons in copper

```
// Exa 2.6
clc;
clear;
close;
// Given data
N = 6.02*10^23;
A = 63.5;// atomic weight
Rho = 1.7*10^-6;// in ohm cm
d = 8.96;// in gm/cc
n = (N/A)*d;// in /cc
e = 1.6*10^-19;// in C
Miu_e = 1/(Rho*n*e);// in cm^2/volt-sec
disp(Miu_e,"The mobility of electron in cm^2/volt.
   sec is");
```

Scilab code Exa 2.7 Density of free electrons

```
// Exa 2.7
clc;
clear;
close;
// Given data
d = 8.96;// in gm/cc
At = 63.5;// atomic weight
N_A = 6.02*10^23;// in /gm mole
l = 0.1;// in m
e = 1.6*10^-19;// in C
A = 1.7*10^-6;// in m^2
R = 0.1;// in ohm
n = (N_A/At)*d;// in /cc
n = n * 10^6;// in /m^3
Rho = (R*A)/l;// in ohm.m
Sigma = 1/Rho;// in mho/m
Miu_e = Sigma/(n*e);// in m^2/V-sec
disp(Miu_e,"The electron mobility in m^2/V-sec is ")
```

```
;
```

Scilab code Exa 2.8 Drift velocity

```
// Exa 2.8
clc;
clear;
close;
// Given data
N_A = 6.025*10^23;// in /gm mole
d = 10.5;// in gm/cc
At = 108;// atomic weight of
n = (N_A/At)*d;// in /cm^3
n = n * 10^6;// in /m^3
r = 10^-3;// in m
A = %pi * ((r)^2);// in m^2
q = 1.6*10^-19;
I = 2;// in A
V = I/(n*q*A);// in m/s
disp(V,"The drift velocity of an electron in m/s is");

// Note: There is calculation error to find the value of V (i.e. drift velocity), So the answer in the book is wrong
```

Scilab code Exa 2.9 Mobility of charge carriers

```
// Exa 2.9
clc;
clear;
close;
// Given data
```

```
e= 1.6*10^-19;// in C
d= 1.03;// in mm
d= d*10^-3;// in m
R= 6.51;// in ohm
l= 300;// in m
n= 8.4*10^28;// per m^3
r= d/2;// in m (radius)
A= %pi*r^2;// in m^2
rho= R*A/l;// in ohm meter
sigma=  1/rho;// in mho/m
disp(sigma,"The coductivity of copper in mho/m is :
    ")
miu_e= sigma/(n*e);// m^2/V-sec
disp(miu_e,"The mobility of charge carriers in m^2/V
    -sec is : ")
```

Scilab code Exa 2.10 Conductivity of pure Si

```
// Exa 2.10
clc;
clear;
close;
// Given data
Miu_e = 1500;// in cm^2/volt.sec
Miu_h = 500;// in cm^2/volt.sec
n_i = 1.6*10^10;// in /cm^3
e = 1.6*10^-19;// in C
Sigma_i = n_i*(Miu_e+Miu_h)*e;// in mho/cm
Sigma = Sigma_i;// in mho/cm
disp(Sigma,"The conductivity of pure silicon in mho/
    cm is");
```

Scilab code Exa 2.11 Number of donor atoms

```
// Exa 2.11
clc;
clear;
close;
// Given data
Miu_d = 500;// in cm^2/V.S
Rho = 10;// in ohm cm
e = 1.6*10^-19;// in C
n_d = 1/(Rho*e*Miu_d);// in /cm^3... correction
disp(n_d,"The number of donor atom per cm^3 is");
```

Scilab code Exa 2.12 Conductivity of speciman

```
// Exa 2.12
clc;
clear;
close;
// Given data
d = 5.32;// in gm/cc
N_A = 6.02*10^23;// in atoms/gm.mole
At = 72.6;//atomic weight
Miu = 3800;// in cm^2/v.s
n_d = (N_A/At) * d;// in /cm^3
n_d = n_d * 10^-8;// in /cc
e = 1.6*10^-19;// in C
Sigma = n_d * Miu * e;// in mho/cm
disp(Sigma,"The conductivity of specimen in mho/cm
   is");
```

Scilab code Exa 2.13 Mobility of electrons in Ge

```
// Exa 2.13
clc;
```

```
clear;
close;
// Given data
Rho = 0.3623*10^-3;// in ohm m
d = 4.42*10^28;// Ge density in atoms/m^3
Sigma = 1/Rho;// in mho/m
n_d = d*10^-6;// in atoms/m^3
e = 1.6*10^-19;// in C
Miu = Sigma/(n_d*e);// in m^2/V.sec
disp(Miu,"The electron mobility in m^2/V-sec is");
```

Scilab code Exa 2.14 Density and mobility of holes

```
// Exa 2.14
clc;
clear;
close;
// Given data
N_A = 6.025*10^26;// in /kg.Mole
At = 72.59;// atomic weight
d = 5.36*10^3;// in kg/m^3
R = 0.42;// in ohm m
B_i = 10^-6;//rate of boron impurity in %
e = 1.6*10^-19;// in C
n = (N_A/At)*d;// number of Ge atoms
h = n/10^8;//holes per unit volume
Miu_h = 1/(R*h*e);// in m^2/V.sec
disp(Miu_h,"The Mobility of holes in m^2/V-sec is");
```

Scilab code Exa 2.15 Current produced

```
// Exa 2.15
clc;
```

```
clear;
close;
// Given data
n_i = 2*10^19;// in /m^3
Miu_e = 0.36;// in m^2/v.s
Miu_h = 0.17;// in m^2/v.s
A = 1*10^-4;// in m^2
V = 2;// in Volts
l = 0.3;// in mm
l = l * 10^-3;// in m
e = 1.6*10^-19;// in C
Sigma_i = n_i * e * (Miu_e+Miu_h);// in mho/m
I = (Sigma_i * V*A)/l;// in amp
disp(I,"The current in amp is");
```

Scilab code Exa 2.16 Resistivity of doped Ge

```
// Exa 2.16
clc;
clear;
close;
// Given data
d = 4.2*10^28;// in atoms/m^3
n_d = d/10^6;// in atoms/m^3
e = 1.6*10^-19;// in C
Miu_e = 0.36;// in m^2/V-sec
Sigma_n = n_d *e *Miu_e;// in mho/m
Rho_n = 1/Sigma_n;// in ohm m
disp(Rho_n,"The resistivity in  m is");
```

Scilab code Exa 2.17 Current produced

```
// Exa 2.17
```

```
clc;
clear;
close;
// Given data
n_i = 1*10^19;// in /m^3
Miu_e = 0.36;// in m^2/volt.sec
Miu_h = 0.17;// in m^2/volt.sec
A = 2;// in cm^2
A = A *  10^-4;// in m^2
t = 0.1;// in mm
t = t*10^-3;// in m
V = 4;// in volts
e = 1.6*10^-19;// in C
Sigma_i = n_i * e * (Miu_e + Miu_h);// mho/m
J = Sigma_i * (V/t);// in Amp/m^2
I = J*A;// in Amp
disp(I,"The current in Amp is");
```

Scilab code Exa 2.18 Conductivity of pure Si

```
// Exa 2.18
clc;
clear;
close;
// Given data
Miu_h = 500;// in cm^2/V.s
Miu_e = 1500;// in cm^2/V.s
n_i = 1.6*10^10;// in /cm^3
e = 1.6*10^-19;// in C
Sigma_i = n_i * e * (Miu_e+Miu_h);// in mho/cm
disp(Sigma_i,"The conductivity of pure silicon in
   mho/cm is");
```

Scilab code Exa 2.19 Hall voltage produced

```
// Exa 2.19
clc;
clear;
close;
// Given data
Si_density = 10.5;// in gm/cc
N_A = 6.025*10^23;
At = 108;//atomic weight
B = 0.8;// in Tesla
w = 0.50;// in cm
w = w * 10^-2;// in m
t = 0.10;// in mm
t = t * 10^-3;// in m
A = w*t;// in m^2
q = 1.6*10^-19;// in C
I = 2;// in ampere
n = (N_A/At) * Si_density ;// in /cc
n = n * 10^6;// in /m^3
V_H = (B*I*t)/(n*q*A);// in volts
disp(V_H,"The hall voltage produced in volts is");
```

Scilab code Exa 2.20 Hall coefficient and mobility of electrons

```
// Exa 2.20
clc;
clear;
close;
// Given data
Sigma = 5.8*10^7;// in mho/m
l = 1;// in m
d = 1;// in cm
d = d * 10^-2;// in m
W = 1;// in mm
```

```
W = W*10^-3;// in m
I = 1;// in Amp
B = 1;// in Tesla
V_H = 0.074*10^-6;// in Volts
A = 10^-2 * 10^-3;// in m^2
R_H = (V_H*A)/(B*I*d);// in m^3/c
disp(R_H,"Hall coefficient in m^3/c is");
Miu = Sigma * R_H;// in m^2/volt.sec
disp(Miu,"The mobility of electron in m^2/volt.sec
    is");
```

Scilab code Exa 2.21 Ratio of electron to hole concentration

```
// Exa 2.21
clc;
clear;
close;
// Given data
n_i = 1.4*10^18;// in /m^3
n_D = 1.4*10^24;// in /m^3
n = n_D;// in /m^3
p = n_i^2/n;// in /m^3
disp(p,"Concentration of holes per m^3 is");
R_e = n/p;// Ratio of electron
disp(R_e,"Ratio of electron to hole concentration is
    ");
```

Scilab code Exa 2.22 Hall angle

```
// Exa 2.22
clc;
clear;
close;
```

```
// Given data
B = 0.48;// in Wb/m^2
R_H = 3.6 * 10^-4;// in m^3/c
R = 9*10^-3;// in ohm-m
Sigma = 1/R;// in (ohm-m)^-1
Rho = 1/R_H;// in coulomb/m^3
e = 1.6*10^-19;// in C
n = Rho/e;// in /m^3
Miu = Sigma * R_H;// in m^2/volt-s
disp(Miu,"The mobility of electron in m^2/volt-s is"
    );
```

Scilab code Exa 2.23 Current density in speciman

```
// Exa 2.23
clc;
clear;
close;
// Given data
e = 1.6*10^-19;// in C
R_H = 0.0145;// in m^3/coulomb
Miu_e = 0.36;// m^2/v-s
E = 100;// V/m
n = 1/(e*R_H);// in /m^3
J= n*e*Miu_e*E;// in A/m^2
disp(J,"The current density in A/m^2 is");
```

Scilab code Exa 2.24 Relaxation time

```
// Exa 2.24
clc;
clear;
close;
```

```
// Given data
e = 1.6*10^-19;// in C
Miu_e = 7.04*10^-3;// in m^2/volt-sec
n = 5.8*10^28;// number of electron/m^3
m = 9.1*10^-31;
E_F = 5.5;// in eV
Torque = (Miu_e/e)*m;// in sec
disp(Torque,"Relaxtion time in sec is");
Rho = 1/(n*e*Miu_e);// in ohm cm
disp(Rho,"Resistivity of conductor in  m is");
V_F = sqrt( (2*E_F*e)/m );// in m/s
disp(V_F,"Velocity of electron with the fermi energy
    in m/s is");

// Note: The calculation of Part (ii) is wrong also
   the unit of resistivity of conductor is wrong
```

Scilab code Exa 2.25 Temperature

```
// Exa 2.25
clc;
clear;
close;
// Given data
E= 5.95;// in eV
EF= 6.25;// in eV
delE= 0.01;
 // delE= 1-1/(1+exp((E-EF)/KT))
K=1.38*10^-23;// Boltzman Constant in J/K
T = ((E-EF)/log(1/(1-delE) -1)*1.6*10^-19)/K;// in K
disp(T,"The temperature in K is : ")
```

Scilab code Exa 2.26 Thermal equilibrium hole concentration

```
// Exa 2.26
clc;
clear;
close;
// Given data
T1 = 400;// in K
T2 = 300;// in K
N_V = 1.04*10^19;// in cm^-3
N1 = N_V*((T1/T2)^(3/2));// in cm^-3
KT = 0.0259*(T1/T2);// in eV
FermiLevel= 0.27;// in eV
P_O = N1*exp( (-FermiLevel)/KT );// in cm^-3
disp(P_O,"The thermal equillibrium hole
    concentration in cm^-3 is");
```

Scilab code Exa 2.27 Required doping concentration

```
// Exa 2.27
clc;
clear;
close;
// Given data
T1 = 550;// in K
T2 = 300;// in K
N1 = 1.04*10^19;
N_V = N1*((T1/T2)^(3));
N_C = 2.8*10^19;
E_g = -1.12;
KT = 0.0259*(T1/T2);
n_i = sqrt(N_C*N_V*exp(E_g/KT));// in cm^-3
disp(n_i,"The value of n_i in cm^-3 is : ")
//Formula n_o= Nd/2+sqrt((Nd/2)^2+n_i^2) and n_o =
    1.05*N_d;
Nd= sqrt(n_i^2/((1.05-1/2)^2-(1/2)^2))
disp(Nd,"The value of N_d in cm^-3 is : ")
```

Scilab code Exa 2.28 Quasi Fermi energy levels

```
// Exa 2.28
clc;
clear;
close;
// Given data
n_o = 10^15;// in cm^-3
n_i = 10^10;// in cm^-3
p_o = 10^5;// in cm^-3
del_p = 10^13;// in cm^-3
del_n = del_p;// in cm^-3
KT= 0.0259;// in eV
Fermi_level= KT*log(n_o/n_i);// in eV
disp(Fermi_level,"Fermi level for thermal
    equillibrium in eV is :")
Fermi_level= KT*log((n_o+del_n)/n_i);// in eV
disp(Fermi_level,"Quasi-Fermi level for electrons in
    non equillibrium in eV is :")
Fermi_level= KT*log((p_o+del_p)/n_i);// in eV
disp(Fermi_level,"Quasi-Fermi level for holes in non
    equillibrium in eV is :")
```

Chapter 3

Excess Carriers In Semiconductors

Scilab code Exa 3.1 Hole concentration at equilibrium

```
// Exa 3.1
clc;
clear;
close;
// Given data
n_o = 10^17;// in /cm^3
n_i = 1.5*10^10;// in /cm^3
p_o = ((n_i)^(2))/n_o;// in holes/cm^3
disp(p_o,"The hole concentration in holes/cm^3 is ")
    ;
```

Scilab code Exa 3.3 Position of Fermi level

```
// Exa 3.3
clc;
clear;
```

```
close;
// Given data
n_i = 1.5 * 10 ^10;// in /cm^3 for silicon
N_d = 10^17;// in atoms/cm^3
n_o = 10^17;// electrons/cm^3
KT = 0.0259;
// E_r - E_i = KT * log(n_o/n_i)
del_E = KT * log(n_o/n_i);// in eV
disp("The energy band for this type material is Ei +
    "+string(del_E)+" eV");
```

Scilab code Exa 3.4 Diffusion coefficients of electrons

```
// Exa 3.4
clc;
clear;
close;
// Given data
K = 1.38*10^-23;// in J/K
T = 27;// in degree C
T = T + 273;// in K
e = 1.6*10^-19;
Miu = 0.17;// in m^2/v-s
Miu1 = 0.025;// in m^2/v-s
D_n = ((K*T)/e)*Miu;// in m^2/s
disp(D_n,"The diffusion coefficient  of electrons in
    m^2/s is");
D_p = ((K*T)/e)*Miu1;// in m^2/s
disp(D_p,"The diffusion coefficient of holes in m^2/
   s is");
```

Scilab code Exa 3.5 Diffusion length

```
// Exa 3.5
clc;
clear;
close;
// Given data
Miu_n = 0.15;// in m^2/v-s
K = 1.38*10^-23;
T = 300;// in K
e = 1.6*10^-19;// in C
D_n = Miu_n*((K*T)/e);// in m^2/s
Torque_n = 10^-7;// in s
L_n = sqrt(D_n*Torque_n);// in m
disp(L_n,"The diffusion length in m is");
del_n = 10^20;// in electrons/m^3
J_n = (e*D_n*del_n)/L_n;// in A/m^2
disp(J_n,"The diffusion current density in A/m^2 is"
    );
```

Scilab code Exa 3.6 Concentration of holes and electrons

```
// Exa 3.6
clc;
clear;
close;
// Given data
Sigma_n = 0.1;// in (ohm-cm)^-1
Miu_n = 1300;
q = 1.6*10^-19;// in C
n_n = Sigma_n/(Miu_n*q);// in electrons/cm^3
disp(n_n*10^6,"Concentration of electrons per m^3 is
    ");
n_i = 1.5*10^10;
p_n = ((n_i)^2)/n_n;// in holes/cm^3
p_n = p_n * 10^6;// in holes/m^3
disp(p_n,"Concentration of holes per m^3 is");
```

Scilab code Exa 3.7 Electron transit time

```
// Exa 3.7
clc;
clear;
close;
// Given data
L = 100*10^-6;// in m
Miu_e = 0.13;// in m^2/V-s
Torque_h = 10^-6;// in s
Miu_h = 0.05;// in m^2/v-s
V = 12;// in V
Torque_n = ((L)^2)/(Miu_e*V);// in s
disp(Torque_n,"Electron transit time in sec is");
P = (Torque_h/Torque_n)*(1+(Miu_h/Miu_e));
disp(P,"Photoconductor gain is");
```

Scilab code Exa 3.8 Resistivity drops

```
//Exa 3.8
clc;
clear;
close;
// Given data
q = 1.6*10^-19;// in C
n_i = 2.5*10^13;
Miu_n = 3800;// in cm^2/V-s
Miu_p = 1800;// in cm^2/V-s
Sigma = n_i*(Miu_n + Miu_p)*q;// in (ohm-cm)^-1
Rho = 1/Sigma;// in ohm-cm
disp(Rho,"The resistivity in ohm-cm is");
```

```
N_D =4.4*10^22/10^8 ;// in atoms/cm^3
Sigma_n = N_D * Miu_n*q;// in (ohm-cm)^-1
Rho1 = 1/Sigma_n;// in ohm cm
disp(Rho1,"The resistivity drops in ohm cm is");
```

Scilab code Exa 3.9 Electron concentration

```
// Exa 3.9
clc;
clear;
close;
// Given data
n_i = 10^16;// in /m^3
N_D = 10^22;// in /m^3
n = N_D;// in /m^3
disp(n,"The concentration of electrons per m^3 is");
p = ((n_i)^2)/n;// in /m^3
disp(p,"The concentration of holes per m^3 is");
```

Scilab code Exa 3.10 Ratio of donor atoms to Si atom

```
// Exa 3.10
clc;
clear;
close;
// Given data
Rho = 9.6*10^-2;// ohm-m
Sigma_n = 1/Rho;// in (ohm-m)^-1
Miu_n = 1300;// in cm^2/V-s
Miu_n = Miu_n * 10^-4;// in m^2/V-s
q = 1.6*10^-19;// in C
N_D = Sigma_n/(Miu_n*q);// in atoms/m^3
d = 5*10^22;// in atoms/cm^3
```

```
d = d * 10^6;// in atoms/m^3
R_d = N_D/d;//  Ratio
disp(R_d,"Ratio of donor atom to silicon atoms per
    unit volume is");
```

Scilab code Exa 3.11 Equillibrium electron and hole densities

```
// Exa 3.11
clc;
clear;
close;
// Given data
n_i = 1.5*10^10;// in /cm^3
n_n = 2.25*10^15;//in /cm^3
p_n = ((n_i)^2)/n_n;// in /cm^3
disp(p_n,"The concentration of holes per cm^3 is");
disp(n_n,"Donor impurity per cm^3 is");
```

Scilab code Exa 3.12 Carrier concentration

```
// Exa 3.12
clc;
clear;
close;
// Given data
N_A = 2*10^16;// in /cm^3
N_D = 10^16;// in /cm^3
C = N_A-N_D;// in /cm^3
disp(C,"Carrier concentration in holes/cm^3 is");
```

Scilab code Exa 3.13 Generation rate due to irradiation

```
// Exa 3.13
// GIven data
clc;
clear;
close;
del_n = 10^15;// in /cm^3
Torque_p = 10*10^-6;// in sec
R_G = del_n/Torque_p;// in electron hole pairs/sec/
    cm^3
disp("The rate of generation of minority carrier is
    : "+string(R_G)+" electron hole pairs/sec/cm^3");
```

Scilab code Exa 3.14 Mobility of minority charge carrier

```
// Exa 3.14
clc;
clear;
close;
// Given data
V = 1/20;// in cm/ sec
V=V*10^6;// in cm/sec
E = 10;// in V/cm
Miu = V/E;// in cm^2/V-sec
disp(Miu,"The mobility of minority charge carrier in
     cm^2/V-sec is");
```

Scilab code Exa 3.15 Hole and electron diffusion current

```
// Exa 3.15
clc;
clear;
```

```
close;
// Given data
q = 1.6 * 10^-19;// in C
N_D = 4.5 * 10^15;// in /cm^3
del_p = 10^21;
e=10;// in cm
A = 1;// in mm^2
A = A * 10^-14;// cm^2
l = 10;// in cm
Torque_p = 1;// in microsec
Torque_p = Torque_p * 10^-6;// in sec
Torque_n = 1;// in microsec
Torque_n = Torque_n * 10^-6;// in  sec
n_i = 1.5 * 10^10;// in /cm^3
D_n = 30;// in cm^2/sec
D_p = 12;// in cm^2/sec
n_o = N_D;// in /cm^3
p_o = (n_i)^2/n_o;// in /cm^3
disp(p_o,"Hole concentration at thermal equilibrium per cm^3 is");
l_n = sqrt(D_n * Torque_n);// in cm
disp(l_n,"Diffusion length of electron in cm is");
l_p = sqrt(D_p * Torque_p);// in cm
disp(l_p,"Diffusion length of holes in cm is");
x=34.6*10^-4;// in cm
dpBYdx = del_p *e;// in cm^4
disp(dpBYdx,"Concentration gradient of holes at distance in cm^4 is");
e1 = 1.88 * 10^1;// in cm
dnBYdx = del_p * e1;// in cm^4 check this also ...........................
disp(dnBYdx,"Concentration gradient of electrons in per cm^4 is");
J_P = -(q) * D_p * dpBYdx;// in A/cm^2
disp(J_P,"Current density of holes due to diffusion in A/cm^2 is");
J_n = q * D_n * dnBYdx;// in A/cm^2
disp(J_n,"Current density of electrons due to
```

```
    diffusion in A/cm^2 is");
```

Scilab code Exa 3.16 Energy band gap of semiconductor material used

```
// Exa 3.16
clc;
clear;
close;
// Given data
h = 6.626 * 10^-34;// in J-s
q= 1.6*10^-19;// in C
h= h/q;// in eV
c = 3*10^8;
lembda = 5490*10^-10;// in m
E = h*c/lembda;// in eV
disp(E,"The energy band gap in eV is");
```

Scilab code Exa 3.17 Current density in Si

```
// Exa 3.17
clc;
clear;
close;
// Gievn data
D_n = 35;// in cm^2/sec
q = 1.6*10^-19;// in C
y2 = 6*10^16;// in /cm^3
y1 = 10^17;// in /cm^3
x2 = 2*10^-4;
x1 = 0;
dnBYdx = (y2-y1)/(x2-x1);
J_n = q*D_n*dnBYdx;// in A/cm^2
disp(J_n,"The current density in A/cm^2 is");
```

Scilab code Exa 3.18 Resistance of the bar

```
// Exa 3.18
clc;
clear;
close;
// Given data
q = 1.6*10^-19;// in C
n_n = 5*10^20;// in  /m^3
n_n = n_n * 10^-6;// in /cm^3
Miu_n = 0.13;// in m^2/V-sec
Miu_n = Miu_n * 10^4;// in cm^2/V-sec
Sigma_n = q*n_n*Miu_n;// in ohm-cm^-1
Rho = 1/Sigma_n;
A = 100;// in  m ^2
A = A * 10^-8;// in cm^2
l = 0.1;// in cm
R = Rho * (l/A);// in ohm
disp(round(R*10^-6),"The resistance of the bar in M
   ohm is");
```

Scilab code Exa 3.19 Depletion width

```
// Exa 3.19
clc;
clear;
close;
// Given data
w = 3;// in  m
D = w/9;// in  m
disp(D,"Depletion width on P side in  m is");
```

Scilab code Exa 3.20 Minority carrier density

```
// Exa 3.20
clc;
clear;
close;
// Given data
n_i = 1.5*10^16;// in /m^3
n_n = 5*10^20;// in /m^3
p_n = ((n_i)^2)/n_n;// in /m^3
disp(p_n,"The minority carrier density per m^3 is");
```

Scilab code Exa 3.21 Collector current density

```
// Exa 3.21
clc;
clear;
close;
// Given data
y2 = 10^14;// in /cm^3
y1 = 0;
x1=-0.5;// in  m
x1= x1*10^-4;// in cm
x2=0;
dnBYdx = (y2-y1)/(x2-x1);// in /cm^4
q = 1.6*10^-19;// in C
D_n = 25;// in cm^2/sec
J_n = q*D_n*dnBYdx;// in A/cm^2
disp(J_n,"The collector current density in A/cm^2 is
    ");
```

Scilab code Exa 3.22 Band gap

```
// Exa 3.22
clc;
clear;
close;
// Given data
h = 6.64*10^-34;// in J-s
q=1.6*10^-19;// in C
h= h/q;// in eV
c = 3*10^8;// in m/s
lembda = 0.87*10^-6;// in m
E_g = (h*c)/lembda;// in eV
disp(E_g,"The band gap in eV is");
```

Scilab code Exa 3.23 Total energy absorbed by sample

```
// Exa 3.23
clc;
clear;
close;
// Given data
alpha = 5*10^4;// in cm^-1
l = 0.46*10^-4;// in cm
hv = 2;// in eV
I_o = 10^-2;// in W
I_t = I_o*exp(-alpha*l);// in W
A_p = I_o-I_t;//absorbed power in W or J/s
disp(A_p,"Total energy absorbed in J/s is");
c = 1.43;
A_E = (hv-c)/hv*A_p;// in J/s
disp(A_E,"Rate of excess thermal energy in J/s is");
```

```
e = 1.6*10^-19;// in C
P = A_p/(e*hv);//Perfect quantum efficiency in
    photon/s
disp(P,"Perfect quantum efficiency in photon/s is");
```

Scilab code Exa 3.24 Hole current

```
// Exa 3.24
clc;
clear;
close;
// Given data
format('v',13)
Mu_p = 500;// in cm^2/v-s
kT = 0.0259;
Toh_p = 10^-10;// in sec
p_o = 10^17;// in cm^-3
q= 1.6*10^-19;// in C
A=0.5;// in square meter
del_p = 5 * 10^16;// in cm^-3
n_i= 1.5*10^10;// in cm^-3
D_p = kT * Mu_p;// in cm/s
L_p = sqrt(D_p * Toh_p);// in cm
x = 10^-5;// in cm
p = p_o+del_p* %e^(x/L_p);// in cm^-3
// p= n_i*%e^(Eip)/kT where Eip=E_i-F_p
Eip= log(p/n_i)*kT;// in eV
Ecp= 1.1/2-Eip;// value of E_c-E_p in eV
Ip= q*A*D_p/L_p*del_p*%e^(x/L_p);// in A
disp(Ip,"The hole current in A is : ")
Qp= q*A*del_p*L_p;// in C
disp(Qp,"The value of Qp in C is : ")

// Note: There is a calculation error to evalaute
    the value of hole current hence the value of hole
```

current in the book is wrong

Chapter 4

Junctions and Interfaces

Scilab code Exa 4.2 Junction width

```
// Exa 4.2
clc;
clear;
close;
// Given data
N_D = 10^17 * 10^6;// in atoms/m^3
N_A = 0.5*10^16*10^6;// in atoms/m^3
Epsilon_r = 10;
Epsilon_o = 8.85*10^-12;
Epsilon = Epsilon_r*Epsilon_o;// in F/m
e = 1.602*10^-19;// in C
V = 0;
V_B = 0.7;// in V
W = sqrt( ((2*Epsilon*V_B)/e)*(1/N_A+1/N_D) );// in m
disp(W,"The junction width in meter when no external voltage is applied is");
V_o = V_B;// in V
V1 = -10;// in V
V_B1 = V_o-V1;// in V
W = sqrt( ((2*Epsilon*V_B1)/e)*(1/N_A+1/N_D) );// in
```

```
m
disp(W,"Junction width in meter with an external
    voltage of -10V is");
```

Scilab code Exa 4.4 Diode voltage

```
// Exa 4.4
clc;
clear;
close;
// Given data
V = 5;// in V
V_Gamma = 0.6;// in V
r_F = 12;// in ohm
R = 1;// in k ohm
R = R * 10^3;// in ohm
I_F = (V-V_Gamma)/(R+r_F);// in A
disp(I_F*10^3,"The forward diode current in mA is");
V_F = V_Gamma + (I_F*r_F);// in V
disp(V_F,"The diode voltage in V is");
```

Scilab code Exa 4.5 Contact difference of potential

```
// Exa 4.5
clc;
clear;
close;
// Given data
n = 4.4*10^22;// total number of Ge atoms/cm^3
n_a = 1*10^8;// number of impurity atoms
N_A = n/n_a;// in atoms/cm^3
N_A = N_A * 10^6;// in atoms/m^3
n_i = 2.5*10^13;// in atoms/cm^3
```

```
n_i = n_i * 10^6;// in atoms/m^3
N_D = 10^3 * N_A;// in atoms/m^3
V_T = 26*10^-3;// in A
V_J = V_T*log( (N_A*N_D)/((n_i)^2) );// in V
disp(V_J,"The contact difference of potential in V
    is");
disp("For a silicon P-N junction")
n = 5*10^22;
N_A = n/n_a;// in atoms/cm^3
N_A = N_A * 10^6;// in atoms/m^3
N_D = 10^3 * N_A;// in atoms/m^3
n_i = 1.5*10^10;// in /cm^3
V_J = V_T*log(N_A*N_D/n_i^2);// in V
disp(V_J,"The contact difference of potential in V
    is");

// Note: There is a calculation error to find the
    value of V_J in the book, so the answer in the
    book is wrong.
```

Scilab code Exa 4.6 Height of the potential energy barrier

```
// Exa 4.6
clc;
clear;
close;
// Given data
Rho_p = 2;// in ohm-cm
Rho_n = 1;// in ohm cm
q = 1.6*10^-19;// in C
n_i = 2.5*10^13;// atoms per cm^3
Miu_p = 1800;
Miu_n = 3800;
N_A = 1/(Rho_p*q*Miu_p);// in /cm^3
N_D = 1/(Rho_n*q*Miu_n);// in /cm^3
```

```
V_T = 26;//in mV
V_T= V_T*10^-3;// in V
V_J = V_T*log((N_A*N_D)/((n_i)^2));//in V
disp(V_J,"The height of the potential energy barrier
    in V is");
Miu_p = 500;
N_A = 1/(Rho_p*q*Miu_p);// in /cm^3
Miu_n = 1300;
N_D = 1/(Rho_n*q*Miu_n);// in /cm^3
n_i = 1.5*10^10;
V_J = V_T*log((N_A*N_D)/((n_i)^2));//in V
disp("For silicon P-N juction")
disp(V_J,"The height of the potential energy barrier
    in V is");
```

Scilab code Exa 4.7 Voltage

```
//Exa 4.7
clc;
clear;
close;
// Given data
Eta = 1;
V_T = 26;// in mV
V_T= V_T*10^-3;// in V
// I = I_o * (%e^(V/(Eta*V_T)) - 1) and I = -(0.9) *
    I_o;
V= log(1-0.9)*V_T;// in V
disp(V,"The voltage in volts is : ")
// Part (ii)
V1=0.05;// in V
V2= -0.05;// in V
ratio= (%e^(V1/(Eta*V_T))-1)/(%e^(V2/(Eta*V_T))-1)
disp(ratio,"The ratio of the current for a forward
   bias to reverse bias is : ")
```

```
// Part (iii)
Io= 10;// in  A
Io=Io*10^-3;// in mA
//For
V=0.1;// in V
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I,"For v=0.1 V , the value of I in mA is : ")
//For
V=0.2;// in V
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I,"For v=0.2 V , the value of I in mA is : ")
//For
V=0.3;// in V
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I*10^-3,"For v=0.3 V , the value of I in A is : ")
disp("From three value of I, for small rise in forward voltage, the diode current increase rapidly")
```

Scilab code Exa 4.8 Anticipated factor

```
//Exa 4.8
clc;
clear;
close;
// Given data
// Part (i)
T1= 25;// in  C
T2= 80;// in  C
// Formula Io2= Io1*2^((T2-T1)/10)
AntiFactor= 2^((T2-T1)/10);
disp(round(AntiFactor),"Anticipated factor for Ge is : ")
// Part (ii)
```

```
T1= 25;// in  C
T2= 150;// in  C
AntiFactor= 2^((T2-T1)/10);
disp(round(AntiFactor),"Anticipated factor for Si is
    : ")
```

Scilab code Exa 4.9 Leakage resistance

```
//Exa 4.9
clc;
clear;
close;
// Given data
I=5;// in  A
V=10;// in V
T1= 0.11;// in  C^-1
T2= 0.07;// in  C^-1
// Io+I_R=I                              (i)
// dI_by_dT= dIo_by_dT          (ii)
// 1/Io*dIo_by_dT = T1 and 1/I*dI_by_dT = T2, So
Io= T2*I/T1;// in  A
I_R= I-Io;// in  A
R= V/I_R;// in M
disp(R,"The leakage resistance in M  is : ")
```

Scilab code Exa 4.10 Dynamic resistance

```
//Exa 4.10
clc;
clear;
close;
// Given data
Eta = 1;
```

```
T = 125;// in  C
T = T + 273;// in K
V_T = 8.62 * 10^-5 * 398;// in V
I_o = 30;// in  A
I_o= I_o*10^-6;// in A
v = 0.2;// in V
r_f = (Eta * V_T)/(I_o * %e^(v/(Eta* V_T)));// in ohm
disp(r_f,"The dynamic resistance in the forward direction in ohm is ");
r_r = (Eta * V_T)/(I_o * %e^(-v/(Eta* V_T)));// in ohm
disp(r_r*10^-3,"The dynamic resistance in the reverse direction in kohm is");
```

Scilab code Exa 4.11 Barrier capacitance of a Ge pn junction

```
// Exa 4.11
clc;
clear;
close;
// Given data
epsilon = 16/(36 * %pi * 10^11);// in F/cm
A = 1 * 10^-2;
W = 2 * 10^-4;
C_T = (epsilon * A)/W;// in F
disp(C_T*10^12,"The barrier capacitance in pF is");
```

Scilab code Exa 4.12 Width of the depletion layer

```
//Exa 4.12
clc;
clear;
```

```
close;
//Given data
A = 1;// in mm^2
A = A * 10^-6;// in m^2
N_A = 3 * 10^20;// in atoms/m^3
q = 1.6 *10^-19;// in C
V_o = 0.2;// in V
epsilon_r=16;
epsilon_o= 8.854*10^-12;// in F/m
epsilon=epsilon_r*epsilon_o;
// Part (a)
V=-10;// in V
// V_o - V = 1/2*((q * N_A )/epsilon) * W^2
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
C_T1 = (epsilon * A)/W;// in F
disp(W*10^6,"The width of the depletion layer for an applied reverse voltage of 10V in  m is ");
// Part (b)
V=-0.1;// in V
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
C_T2 = (epsilon * A)/W;// in F
disp(W*10^6,"The width of the depletion layer for an applied reverse voltage of 0.1V in  m is ");
// Part (c)
V=0.1;// in V
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
disp(W*10^6,"The width of the depletion layer for an applied for a forward bias of 0.1V in  m is ");
// Part (d)
disp(C_T1*10^12,"The space charge capacitance for an applied reverse voltage of 10V in pF is");
disp(C_T2*10^12,"The space charge capacitance for an applied reverse voltage of 0.1V in pF is");
```

Scilab code Exa 4.13 Current in the junction

```
// Exa 4.13
clc;
clear;
close;
// Given data
I_o = 1.8 * 10^-9;// A
v = 0.6;// in V
Eta = 2;
V_T = 26;// in mV
V_T=V_T*10^-3;// in V
I = I_o *(%e^(v/(Eta * V_T)));// in A
disp(I*10^3,"The current in the junction in mA is");
```

Scilab code Exa 4.14 Forward biasing voltage

```
// Exa 4.14
clc;
clear;
close;
// Given data
I_o = 2.4 * 10^-14;
I = 1.5;// in mA
I=I*10^-3;// in A
Eta = 1;
V_T = 26;// in mV
V_T= V_T*10^-3;// in V
v =log((I + I_o)/I_o) * V_T;// in V
disp(v,"The forward biasing voltage across the
    junction in V is");
```

Scilab code Exa 4.15 Theoretical diode current

```
// Exa 4.15
clc;
clear;
close;
// Given data
I_o = 10;// in nA
// I = I_o * ((e^(v/(Eta * V_T))) - 1)
// e^(v/(Eta * V_T)<< 1, so neglecting it
I = I_o * (-1);// in nA
disp(I,"The Diode current in nA is  ");
```

Scilab code Exa 4.16 Diode dynamic resistance

```
// Exa 4.16
clc;
clear;
close;
// Given data
R = 4.5;// in ohm
I = 44.4;// in mA
I=I*10^-3;// in A
V = R * I;// in V
Eta = 1;
V_T = 26;//in mV
V_T=V_T*10^-3;// in V
I_o = I/((%e^(V/(Eta * V_T))) -1);// in A
// At
V = 0.1;// in V
r_f = (Eta * V_T)/(I_o * ((%e^(V/(Eta * V_T))-1));
    // in ohm
disp(r_f,"The diode dynamic resistance in    is");
```

Scilab code Exa 4.17 DC load line and operating point

```
// Exa 4.17
clc;
clear;
close;
// Given data
V_D = 10;// in V
// V_S = i*R_L + V_D
V_S = V_D;// in V (i * R_L = 0)
disp(V_S,"when diode is OFF, the voltage in volts is : ");
R_L = 250;// in ohm
I = V_S/R_L;// in A
disp(I*10^3,"when diode is ON, the current in mA is");
V_D= 0:0.1:10;// in V
I= (V_S-V_D)/R_L*1000;// in mA
plot(V_D,I)
xlabel("V_D in volts");
ylabel("Current in mA")
title("DC load line");
disp("DC load line shown in figure")
```

Scilab code Exa 4.18 AC resistance of a Ge diode

```
// Exa 4.18
clc;
clear;
close;
// Given data
V = 0.25;// in V
I_o = 1.2;// in  A
I_o = I_o * 10^-6;// in A
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
Eta = 1;
```

```
r = (Eta * V_T)/(I_o * (%e^(V/(Eta * V_T))));// in ohm
disp(r,"The ac resistance of the diode in ohm is");
```

Scilab code Exa 4.19 Width of the depletion layer

```
// Exa 4.19
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
N_A = 3 * 10^20;// in /m^3
A = 1;// in  m ^2
A = A * 10^-6;// in m^2
V = -10;// in V
V_J = 0.25;// in V
V_B = V_J - V;// in V
epsilon_o = 8.854;// in pF/m
epsilon_o = epsilon_o * 10^-12;// in F/m
epsilon_r = 16;
epsilon = epsilon_o * epsilon_r;
W = sqrt((V_B * 2 * epsilon)/(q * N_A));// in m
disp(W*10^6,"The width of depletion layer in  m is");
C_T = (epsilon * A)/W;// in pF
disp(C_T*10^12,"the space charge capacitance in pF is");
```

Scilab code Exa 4.20 Diameter

```
// Exa 4.20
clc;
```

```
clear;
close;
// Given data
C_T = 100;// in pF
C_T=C_T*10^-12;// in F
epsilon_r = 12;
epsilon_o = 8.854 * 10^-12;// in F/m
epsilon = epsilon_r * epsilon_o;
Rho_p = 5;// in ohm-cm
Rho_p = Rho_p * 10^-2;// in ohm-m
V_j = 0.5;// in V
V = -4.5;// in V
Mu_p = 500;// in cm^2
Mu_p = Mu_p * 10^-4;// in m^2
Sigma_p = 1/Rho_p;// in per ohm-m
qN_A = Sigma_p/ Mu_p;
V_B = V_j - V;
W = sqrt((V_B * 2 * epsilon)/qN_A);// in m
//C_T = (epsilon * A)/W;
A = (C_T * W)/ epsilon;// in m
D = sqrt(A * (4/%pi));// in m
D = D * 10^3;// in mm
disp(D,"The diameter in mm is");
```

Scilab code Exa 4.21 Temperature of junction

```
// Exa 4.21
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
Mu_p = 500;// in cm^2/V-sec
Rho_p = 3.5;// in ohm-cm
Mu_n = 1500;// in cm^2/V-sec
```

```
Rho_n = 10;// in ohm-cm
N_A = 1/(Rho_p * Mu_p * q);// in /cm^3
N_D = 1/(Rho_n * Mu_n * q);// in /cm^3
V_J = 0.56;// in V
n_i = 1.5 * 10^10;// in /cm^3
V_T = V_J/log((N_A * N_D)/(n_i)^2);// in V
// V_T = T/11600
T = V_T * 11600;// in K
T = T - 273;// in  C
disp(T,"The Temperature of junction in  C is");
```

Scilab code Exa 4.22 Reverse saturation current

```
// Exa 4.22
clc;
clear;
close;
// Given data
R = 5;// in ohm
I = 50;// in mA
I=I*10^-3;// in A
V = R * I;// in V
Eta = 1;
V_T = 26;// in mV
V_T=V_T*10^-3;// in V
I_o = I/((%e^(V/(Eta * V_T))) - 1);// in A
disp(I_o*10^6,"Reverse saturation current in  A is");
v1 = 0.2;// in V
r = (Eta * V_T)/(I_o * (%e^(v1/(Eta * V_T))));// in ohm
disp(r,"Dynamic resistance of the diode in  is");
```

Chapter 6

Microwave Diodes

Scilab code Exa 6.1 Tuning range of circuit

```
// Exa 6.1
clc;
clear;
close;
// Given data
C1_min= 5;// in pF
C1_max= 50;// in pF
C2_min= 5;// in pF
C2_max= 50;// in pF
C1_min=C1_min*10^-12;// in F
C2_min=C2_min*10^-12;// in F
C1_max=C1_max*10^-12;// in F
C2_max=C2_max*10^-12;// in F
L = 10;// in mH
L = L * 10^-3;// in H
C_T_min = (C1_min*C2_min)/(C2_min+C2_min);// in F
f_o_max = 1/( 2*%pi*(sqrt(L*C_T_min)) );//in Hz
f_o_max = f_o_max * 10^-6;// in MHz
C_T_max = (C1_max*C2_max)/(C2_max+C2_max);// in F
f_o_min = 1/( 2*%pi*(sqrt(L*C_T_max)) );//in Hz
f_o_min = f_o_min * 10^-3;// in kHz
```

```
disp("The tuning range for circuit will be : "+
   string(round(f_o_min))+" kHz to "+string(round(
   f_o_max))+" MHz")
```

Chapter 7

Optoelectonic Devices

Scilab code Exa 7.1 Component value

```
// Exa 7.1
clc;
clear;
close;
// Given data
Vout = 5;// in V
V = 1.5;//ON state voltage drop across LED in V
I = 5;// in mA
I = I*10^-3;// in A
R = (Vout-V)/I;// in ohm
disp(R,"Resistance in ohm is");
```

Scilab code Exa 7.2 Open circuit voltage

```
// Exa 7.2
clc;
clear;
close;
```

```
// Given data
N_A = 7.5*10^24;// in atoms/m^3
N_D = 1.5*10^22;// in atoms/m^3
D_e = 25*10^-4;// in m^2/s
D_n = 1*10^-3;// in m^2/s
V_T = 26*10^-3;// in V
Torque_eo = 500*10^-9;// in sec
Torque_ho = 100*10^-9;// in sec
e = 1.6*10^-19; // in C
n_i = 1.5*10^16;// in /m^3
I_lambda = 12.5;// in mA/cm^2
I_lambda= I_lambda*10^-3;// in A/cm^2
L_e = sqrt(D_e*Torque_eo);// in m
L_n = sqrt(D_n*Torque_ho);// in m
J_s = e*((n_i)^2)*( ((D_e)/(L_e*N_A)) + ((D_n)/(L_n*
   N_D)) );// in A/m^2
J_s= J_s*10^-4;// in A/cm^2
V_OC = V_T*(log(1+(I_lambda/J_s)));// in V
disp(V_OC,"Open circuit voltage in volts is");
```

Scilab code Exa 7.3 Photocurrent density

```
// Exa 7.3
clc;
clear;
close;
// Given data
Phi_o = 1*10^21;// in m^-2s^-1
alpha =1*10^5;// in m^-1
e= 1.6*10^-19;// in C
G_L1 = alpha*Phi_o;// in m^-3s^-1
W = 26;// in  m
W = W * 10^-6;// in m
G_L2 = alpha*Phi_o*(%e^((-alpha)*W));// in m^-3s^-1
J_L = e*Phi_o*(1-%e^(-(alpha)*W));// in A/m^2
```

```
J_L = J_L * 10^3*10^-4;// in mA/cm^2
disp(J_L,"Photo current density in mA/cm^2 is ");
```

Chapter 8

Metal Semiconductor Field Effect Transistor

Scilab code Exa 8.1 Drain current

```
// Exa 8.1
clc;
clear;
close;
// Given data
I_DSS = 15;// in mA
V_GS_off = -5;// in V
V_GS = 0;// in V
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS=0, the drain current in mA is");
V_GS = -1;// in V
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS=-1V, the drain current in mA is"
    );
V_GS = -4;// in V
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS=-4 V, the drain current in mA is
    ");
```

Scilab code Exa 8.2 Transconductance curve

```
// Exa 8.2
clc;
clear;
close;
// Given data
V_GS_off = -20;// in V
I_DSS = 12;// in mA
V_GS = 0;// in V
// For
V_GS= -20;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -20 V, the drain current in mA is");
// For
V_GS= -15;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -15 V, the drain current in mA is");
// For
V_GS= -10;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -10 V, the drain current in mA is");
// For
V_GS= -5;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -5 V, the drain current in mA is");
// For
V_GS= 0;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = 0 V, the drain current in mA
```

```
    is");
V_GS= 0:-0.1:-20
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
plot(V_GS,I_D);
xlabel("Gate to source voltage in V")
ylabel("Drain current in mA")
title("The transconductance curve")
disp("The transconductance curve shown in figure")
```

Scilab code Exa 8.3 Maximum and minimum transconductance

```
// Exa 8.3
clc;
clear;
close;
// Given data
// For maximum transconductance curve
disp("For Maximum Transconductance curve")
V_GS_off = -2;// in V
I_DSS = 8;// in mA
V_GS = 0;// in V
// For
V_GS= -2;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -2 V, the drain current in mA
    is");
// For
V_GS= -1.5;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -1.5 V, the drain current in
    mA is");
// For
V_GS= -1;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -1 V, the drain current in mA
```

```
is");
// For
V_GS= -0.5;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -0.5 V, the drain current in mA is");
// For
V_GS= 0;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = 0 V, the drain current in mA is");

// For maximum transconductance curve
disp("For Maximum Transconductance curve")
V_GS_off = -6;// in V
I_DSS = 20;// in mA
V_GS = 0;// in V
// For
V_GS= -6;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -6 V, the drain current in mA is");
// For
V_GS= -4;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -4 V, the drain current in mA is");
// For
V_GS= -2;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = -2 V, the drain current in mA is");
// For
V_GS= 0;
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
disp(I_D,"When V_GS = 0 V, the drain current in mA is");
// For maximum transconductance curve
```

```
V_GS_off=-6;// in V
I_DSS= 20;// in mA
V_GS= 0:-0.1:-6;// in volt
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
// For minimum transconductance curve
plot(V_GS,I_D);
V_GS_off=-2;// in V
I_DSS= 8;// in mA
V_GS= 0:-0.1:-2;// in volt
I_D = I_DSS*((1-(V_GS/V_GS_off))^2);// in mA
plot(V_GS,I_D);
xlabel("Gate to source voltage in V")
ylabel("Drain current in mA")
title("The minimum and maximum transconductance curve")
disp("The minimum and maximum transconductance curve shown in figure")

// Note: For maximum transconductance curve the value of drain current at V_GS =-2 is wrong.
```

Scilab code Exa 8.4 Drain current

```
// Exa 8.4
clc;
clear;
close;
// Given data
I_DSS = 20;// in mA
V_P = -8;// in V
g_mo = 5000;// in  s
V_GS = -4;// in V
I_D = I_DSS*((1-(V_GS/V_P))^2);// in mA
disp(I_D,"The value of drain current in mA is");
g_m = g_mo*(1-(V_GS/V_P));// in  s
```

```
disp(g_m,"The transconductance in   s  is");
```

Scilab code Exa 8.5 Drain current

```
// Exa 8.5
clc;
clear;
close;
// Given data
I_D1 = 10;// in mA
V_GS = -12;// in V
V_GSth = -3;// in V
K = I_D1/( (V_GS-V_GSth)^2 );// in mA/V
V_GS= -6;// in V
I_D = K*((V_GS-V_GSth)^2);// in mA
disp(I_D,"The value of I_D in mA is");
```

Scilab code Exa 8.7 Minimum value of VDS

```
// Exa 8.7
clc;
clear;
close;
// Given data
V_GS = -2;// in V
V_P = -5;// in V
V_DS = V_GS-V_P;// in V
I_DSS = 8;// in mA
disp(V_DS,"The minimum value of V_DS in V is");
I_D = I_DSS*((1-(V_GS/V_P))^2);// in mA
disp(I_D,"The drain current in mA is");
```

Scilab code Exa 8.8 Value of Vgs and gm

```
// Exa 8.8
clc;
clear;
close;
// Given data
V_P = -2;// in V
I_DSS = 1.65;// in mA
I_D = 0.8;// in mA
V_DD = 24;// in V
V_GS = V_P*(1- sqrt(I_D/I_DSS) );// in V
disp(V_GS,"The value of V_GS in V is");
g_mo = -(2*I_DSS)/V_P;// in mS
g_m = g_mo*(1-(V_GS/V_P));// in mS
disp(g_m,"The value of g_m in mS is");
```

Scilab code Exa 8.9 Gate source voltage

```
// Exa 8.9
clc;
clear;
close;
// Given data
V_P = 5;// in V
I_DSS = -40;// in mA
I_D = -15;// in mA
V_GS = V_P*(sqrt(I_D/I_DSS)-1 );// in V
disp(abs(V_GS),"The gate source voltage in V is");
```

Scilab code Exa 8.10 Value of transconductance

```
// Exa 8.10
clc;
clear;
close;
// Given data
I_D1 = 1.9;// in mA
I_D2 = 1;// in mA
del_I_D = I_D1-I_D2;// in mA
V_GS2 = -3.3;// in V
V_GS1 = -3;// in V
del_V_GS = V_GS1-V_GS2;// in V
g_m = del_I_D/del_V_GS;// in mA/V
g_m = g_m * 10^3;// in    mhos
disp(g_m,"The value of transconductance in     mhos is");
```

Scilab code Exa 8.11 AC drain resistance

```
// Exa 8.11
clc;
clear;
close;
// Given data
V_DS1 = 14;// in V
V_DS2 = 5;// in V
del_V_DS = V_DS1-V_DS2;// in V
I_D1 = 3.3;// in mA
I_D2 = 3;// in mA
del_I_D = I_D1-I_D2;// in mA
r_d = del_V_DS/del_I_D;// in k ohms
disp(r_d,"The drain resistance in k ohms is");
V_GS1 = 0.4;// in V
V_GS2 = 0.1;// in V
```

```
del_V_GS = V_GS1-V_GS2;// in V
I_D1 = 3.3;// in mA
I_D2 = 0.71;// in mA
del_I_D = I_D1-I_D2;// in mA
g_m = del_I_D/del_V_GS;// in mA/V
g_m = g_m * 10^3;// in  mhos
disp(g_m,"The transconductance in  mhos is");
Miu =r_d*10^3*g_m*10^-6;
disp(Miu,"Amplification factor is");
```

Scilab code Exa 8.12 Pinch off voltage

```
// Exa 8.12
clc;
clear;
close;
// Given data
q = 1.6*10^-19;// in C
N_D = 10^15*10^6;//electrons/m^3
a = 3*10^-4;// in cm
a=a*10^-2;// in m
Epsilon_o  = (36 * %pi * 10^9)^-1;
Epsilon = 12*Epsilon_o;
V_P = (q*N_D*((a)^2))/(2*Epsilon);// in V
disp(V_P,"Pinch off voltage in V is");
V_GS = 1;// in V
V_P = 2;// in V
// Formula V_GS= V_P*(1-b/a)^2
b = a*( 1-sqrt(V_GS/V_P) );// in m
b = b * 10^6;// in  m
disp(b,"The channel half width in  m is");

// Note: In the book, the unit of channel half width
    is wrong.
```

Scilab code Exa 8.13 Value of VGS

```
// Exa 8.13
clc;
clear;
close;
// Given data
I_DSS = 8;// in mA
V_P = -4;// in V
a = 3*10^-4;// in cm
N_D = 10^15;// in electrons/cm^3
I_D = 3;// in mA
V_GS = V_P*( 1-sqrt(I_D/I_DSS) );// in V
disp(V_GS,"The value of V_GS in V is");
V_DS_sat = V_GS-V_P;// in V
disp(V_DS_sat,"The value of V_DS_sat in V is");
```

Scilab code Exa 8.14 Drain current

```
// Exa 8.14
clc;
clear;
close;
// Given data
V_P = -4;// in V
I_DSS = 9;// in mA
V_GS = -2;// in V
I_D = I_DSS*(( 1-(V_GS/V_P) )^2);// in mA
disp(I_D,"The drain current in mA is");
```

Scilab code Exa 8.15 Value of transconductance

```
// Exa 8.15
clc;
clear;
close;
// Given data
I_DSS = 12;// in mA
V_P = -6;// in V
V_GS = -1;// in V
g_mo = (-2*I_DSS)/V_P;// in mA/V
g_m = g_mo*(1-(V_GS/V_P));// in mS
disp(g_m,"The value of transconductance in mS is");
```

Scilab code Exa 8.16 Value of transconductance

```
// Exa 8.16
clc;
clear;
close;
// Given data
I_DSS = 10;// in mA
V_P = -5;// in V
V_GS = -2.5;// in V
g_m = ((-2*I_DSS)/V_P)*(1-(V_GS/V_P));// in mS ....
   correction
disp(g_m,"The transconductance in mS is");
I_D = I_DSS * ((1-(V_GS/V_P))^2);// in mA
disp(I_D,"The drain current in mA is");
```

Chapter 9

MOS Transistors

Scilab code Exa 9.1 Value of current

```
// Exa 9.1
clc;
clear;
close;
// Given data
V_TN = 0.7;// in V
W = 45*10^-4;// in cm
L = 4;// in  m
L = L * 10^-4;// in cm
t_ox = 450;// in
t_ox = t_ox*10^-8;// in cm
V_GS = 1.4;// in V
Miu_n = 700;// in cm^2/V-s
Epsilon_ox = (8.85*10^-14)*(3.9);// in F/cm
k_n = (W*Miu_n*Epsilon_ox)/(2*L*t_ox);// A/V^2
disp(k_n*10^3,"The value of k_n in mA/V^2 is : ")
I_D = k_n*((V_GS-V_TN)^2);// in A
disp(I_D*10^3,"The current in mA is ");

// Note: There is a calculation error to find the value of k_n, So the answer in the book is wrong
```

Scilab code Exa 9.2 IDQ and VDSQ

```
// Exa 9.2
clc;
clear;
close;
// Given data
I_Don = 6;// in mA
I_Don= I_Don*10^-3;// in A
V_GSon = 8;// in V
V_GSth = 3;// in V
V_DD = 12;// in V
R_D= 2*10^3;// in
k= I_Don/(V_GSon-V_GSth)^2;// in A/V^2
// I_D= k*[V_GS-V_GSth]^2 but V_GS= V_DD-I_D*R_D, So
// I_D= k*(V_DD-I_D*R_D-V_GSth)^2 or
// I_D^2*R_D^2+I_D*(2*R_D*V_GSth-2*R_D*V_DD-1/k)+(V_DD-V_GSth)^2
A= R_D^2;// assumed
B= 2*R_D*V_GSth-2*R_D*V_DD-1/k;// assumed
C= (V_DD-V_GSth)^2;// assumed
root= [A B C]
root= roots(root);// in A
I_DQ= root(2);// in A
disp(I_DQ*10^3,"The value of I_DQ in mA is : ")
V_DSQ= V_DD-I_DQ*R_D;// in V
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 9.3 Biasing circuit

```
// Exa 9.3
```

```
clc;
clear;
close;
// Given data
V_GS = 6;// in V
I_D = 4;// in mA
V_GSth = 2;// in V
V_DS = V_GS;// in V
V_DD = 2*V_DS;// in V
disp(V_DD,"The value of V_DD in V is")
R_D = (V_DD-V_DS)/I_D;// in k ohm
disp(R_D,"The value of R_D in k ohm is ");
disp("The very high value for the gate to drain
    resistance is : 10 M ")
```

Scilab code Exa 9.4 IDQ VGSQ and VDS

```
// Exa 9.4
clc;
clear;
close;
// Given data
I_Don = 3*10^-3;
V_GSon = 10;// in V
V_GSth= 5;// in V
R2= 18*10^6;// in
R1= 22*10^6;// in
R_S=820;// in
R_D=3*10^3;// in
V_DD= 40;// in V
V_G= V_DD*R2/(R1+R2);// in V
k= I_Don/(V_GSon-V_GSth)^2;// in A/V^2
// V_G= V_GS+V_RS= V_GS+I_D*R_S or V_GS= V_G-I_D*R_S
// I_D= k*[V_GS-V_GSth]^2 or
// I_D= k*(V_G-I_D*R_D-V_GSth)^2 or
```

```
// I_D^2*R_D^2+I_D*(2*R_D*V_GSth-2*R_D*V_DD-1/k)+(V_DD-V_GSth)^2
A= R_S^2;// assumed
B= 2*R_S*V_GSth-2*R_S*V_G-1/k;// assumed
C= (V_G-V_GSth)^2;// assumed
I_D= [A B C]
I_D= roots(I_D);// in A
I_D= I_D(2);// in A
I_DQ= I_D;// in A
disp(I_DQ*10^3,"The value of I_DQ in mA is : ")
V_GSQ= V_G-I_D*R_S;// in V
disp(V_GSQ,"The value of V_GSQ in volts is : ")
V_DSQ= V_DD-I_DQ*(R_D+R_S);// in V
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 9.5 IDSQ VGSQ and VDSQ

```
// Exa 9.5
clc;
clear;
close;
// Given data
I_D= '0.3*(V_GS-V_P)^2';// given expression
V_DD= 30;// in V
V_P= 4;// in V
R_GS = 1.2*10^6;// in
R_G = 1.2*10^6;// in
Req= R_GS/(R_GS+R_G);// in
R_D= 15;// in
// V_DS= V_DD-I_D*R_D (applying KVL to drain circuit)
// V_GS= Req*V_DS= (V_DD-I_D*R_D)*Req
// from given expression
//I_D^2*(R_D*Req)^2 - I_D*(2*R_D*Req*(V_DD*Req-V_P)+1/0.3 + (V_DD*Req-V_P)^2)
```

```
A= (R_D*Req)^2;// assumed
B= -(2*R_D*Req*(V_DD*Req-V_P)+1/0.3);// assumed
C= (V_DD*Req-V_P)^2;// assumed
I_D= [A B C]
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
I_DSQ= I_D;// in mA
disp(I_DSQ,"The value of I_DSQ in mA is : ")
V_GS= (V_DD-I_D*R_D);// in V
disp(V_GS,"The value of V_GS in volts is : ")
V_DS= Req*V_GS;// in V
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 9.6 Value of ID and VDS

```
// Exa 9.6
clc;
clear;
close;
// Given data
k = 0.1;// in mA/V^2
V_T  = 1;// in V
R1 = 33;//in k ohm
R2 = 21;// in k ohm
V_DD = 6;// in V
R_D = 18;// in k ohm
V_G = (R2/(R2+R1))*V_DD;// in V
V_S = 0;// in V
V_GS = V_G-V_S;// in V
I_D = k*((V_GS-V_T)^2);// in mA
disp(I_D,"The value of I_D in mA is");
V_DS = V_DD - (I_D*R_D);// in V
disp(V_DS,"The value of V_DS in V is");
V_DSsat = V_GS-V_T;// in V
disp(V_DSsat,"The value of V_DS(sat) in V is");
```

```
if V_DS>V_DSsat then
    disp("MOSFET is in saturation region")
end
```

Scilab code Exa 9.7 DC load line and operating point

```
// Exa 9.7
clc;
clear;
close;
// Given data
V_DD= 6;// in V
R_D= 18;// in kohm
// for maximum value of I_D
V_DS=0;// in V
I_Dmax= (V_DD-V_DS)/R_D;// in mA
// for maximum value of V_DS
I_D=0;// in mA
V_DSmax=V_DD-I_D*R_D;// in V
V_DS= 0:0.1:V_DSmax;// in V
I_D= (V_DD-V_DS)/R_D;// in mA
plot(V_DS,I_D)
xlabel("V_DS in volts")
ylabel("I_D in mA")
title("DC load line")
disp("DC load line shown in figure");
disp("Q-points are : 2.8V,0.178 mA")
```

Scilab code Exa 9.8 Region of MOSFET

```
// Exa 9.8
clc;
clear;
```

```
close;
// Given data
R2 = 18;// in k ohm
R1 = 33;// in k ohm
V_DD = 6;// in V
V_G = (R2/(R1+R2))*V_DD;// in V
V_S = V_DD;// in V
V_SG = V_S-V_G;// in V
disp(V_SG,"The value of V_SG in V is");
k = 0.1;
V_T = -1;// in V
I_D = k*((V_SG+V_T)^2);// in mA
disp(I_D,"The value of I_D in mA is");
R_D = 3;// in k ohm
V_SD = V_DD - (I_D*R_D);// in V
disp(V_SD,"The value of V_SD in V is");
V_SDsat  = V_SG+V_T;// in V
disp(V_SDsat,"The value of V_SD(sat) in V is");
if V_SD>V_SDsat then
    disp("The p MOSFET is indeed biased in the
       saturation region")
end
```

Scilab code Exa 9.9 IDQ and VDSQ

```
// Exa 9.9
clc;
clear;
close;
// Given data
V_G= 1.5;// in V
V_P= -3;// in V
R_S= 750;// in
R_D= 1800;// in
I_DSS= 6*10^-3;// in A
```

```
V_DD= 18;// in V
// V_GS= V_G-I_D*R_S
// I_D= I_DSS*(1-V_GS/V_P)^2 or I_DSS*(1-(V_G-I_D*R_S)/V_P)^2
//I_D^2*R_S^2+I_D*(2*R_S*(V_P-V_G)-V_P^2/I_DSS)+(V_P-V_G)^2
A= R_S^2
B=(2*R_S*(V_P-V_G)-V_P^2/I_DSS)
C=(V_P-V_G)^2
I_D= [A B C]
I_D= roots(I_D);// in A
I_D= I_D(2);// in A
I_DQ= I_D;// in A
V_DS= V_DD-I_D*(R_D+R_S);// in V
V_DSQ= V_DS;// in V
disp(I_DQ*10^3,"The value of I_DQ in mA is : ")
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 9.10 Value of Rs

```
// Exa 9.10
clc;
clear;
close;
// Given data
V_GS = 4;// in V
V_P = 2;// in V
R2 = 10;// in k ohm
R1 = 30;// in k ohm
R_D= 2.5;// in kohm
I_D= 15;// in mA
I_D= I_D*10^-3;// in A
V_DD = 25;// in V
V_G = (V_DD/R_D)*V_DD/(R1+R2);// in V
R_S = (V_G-V_GS)/I_D;// in ohm
```

```
disp(R_S,"The value of R_S in ohm is");
```

Scilab code Exa 9.11 ID and VDS

```
// Exa 9.11
clc;
clear;
close;
// Given data
k= 0.1;// in mA/V^2
V_T= 1;// in V
R2= 87*10^3;// in
R1= 110*10^3;// in
R_S=2;// in k
R_D=2;// in k
//R_D=3*10^3;// in
V_DD= 6;// in V
V_SS= 6;// in V
V_G= (V_DD+V_SS)*R2/(R1+R2);// in V
// V_S= I_D*R_S-V_SS
// V_GS= V_G-V_S= V_G+V_SS-(I_D*R_S)
// I_D= k*[V_GS-V_T]^2 = k*[(V_G+V_SS-V_T)-(I_D*R_S)
    ]^2
//(I_D*R_S)^2-  I_D*(2*R_S*(V_G+V_SS-V_T)+1/k)   +(
    V_G+V_SS-V_T)^2
A= R_S^2;// assumed
B= -(2*R_S*(V_G+V_SS-V_T)+1/k);// assumed
C= (V_G+V_SS-V_T)^2;// assumed
I_D= [A B C]
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
disp(I_D,"The value of I_D in mA is : ")
// Applying KVL to drain source loop , V_DD+V_SS= I_D
    *R_D+V_DS+I_D*R_S
V_DS=V_DD+V_SS-I_D*R_D-I_D*R_S;// in V
```

```
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 9.12 NMOS CS circuit

```
// Exa 9.12
clc;
clear;
close;
// Given data
k = 0.16;// in mA/V^2
V_T = 2;// in V
I_D = 0.5;// in mA
V_DD = 6;// in V
V_SS = -6;// in V
V_GS = V_T + (sqrt(I_D/k));// in V
R_S = 2;// in k ohm
V_S = (I_D*R_S) - V_DD;// in V
V_G = V_GS+V_S;// in V
I = 0.1*I_D;// in mA
R2 = (V_G+V_DD)/I;// in k ohm
disp(R2,"The value of R2 in k ohm is");
R1 = (V_DD - V_G)/I;// in k ohm
disp(R1,"The value of R1 in k ohm is");
R_D = 10;// in k ohm
V_DS = (V_DD-V_SS) - (I_D*(R_S+R_D));// in V
disp(V_DS,"The value of V_DS in V is");
V_DSsat = V_GS-V_T;// in V
disp(V_DSsat,"The value of V_DS(sat) in V is");
if V_DS>V_DSsat then
    disp("The MOSFET is in saturation region")
end

// Note: The value of R1 is in k ohm but in the book
    it is wrong.
```

Scilab code Exa 9.13 Value of IDQ and VDS

```
// Exa 9.13
clc;
clear;
close;
// Given data
V_DD = 6;// in V
V_D = 3;// in V
R_D = 10;// in k ohm
I_DQ = (V_DD-V_D)/R_D;// in mA
disp(I_DQ,"The value of I_DQ in mA is");
V_T = 0.8;// in V
k = 0.12;// in mA/V^2
V_GS = sqrt(I_DQ/k) + V_T;// in V
V_S = -V_GS;// in V
V_DS = V_D-V_S;// in V
disp(V_DS,"The value of V_DS in V is");
```

Scilab code Exa 9.14 Region of MOSFET

```
// Exa 9.14
clc;
clear;
close;
// Given data
I_D = 0.3;// in mA
k = 0.12;// in mA/V^2
V_T = 1;// in V
V_GS = V_T + (sqrt(I_D/k));// in V
V_S = -V_GS;// in V
V_DD = 6;// in V
```

```
V_D = 3;// in V
I_DQ = 0.3;// in mA
R_D = (V_DD-V_D)/I_DQ;// in k ohm
disp(R_D,"The value of R_D in k ohm is");
V_DS = V_D - V_S;// in V
disp(V_DS,"The value of V_DS in V is");
V_DSsat = V_GS - V_T;// in V
disp(V_DSsat,"The value of V_DS(sat) in V is");
if V_DS>V_DSsat then
    disp("The MOSFET is in saturation region")
end
```

Scilab code Exa 9.15 VGS VDS and ID

```
// Exa 9.15
clc;
clear;
close;
// Given data
k= 0.05;// in mA/V^2
V_T= 1;// in V
V_DD= 6;// in V
R_S= 9.1;//in k
//V_GS= V_DD-I_D*R_S
//I_D= k*(V_DD-I_D*R_S)^2
//I_D^2*R_S^2-I_D*(2*V_DD*R_S+1/k)+V_DD^2
A= R_S^2;// assumed
B=-(2*V_DD*R_S+1/k);// assumed
C= V_DD^2;// assumed
I_D= [A B C];
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
V_GS= V_DD-I_D*R_S;// in V
V_DS= V_GS;// in V
disp(I_D,"The value of I_D in mA is : ")
```

```
disp(V_GS,"The value of V_GS in volts is : ")
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 9.16 All dc voltages

```
// Exa 9.16
clc;
clear;
close;
// Given data
k1= 0.01;// in mA/V^2
k2= 0.05;// in mA/V^2
V_DD= 5;// in V
V_T1=1;// in V
V_T2=1;// in V
// Analysis for Vi= 5V
Vi= 5;// in V
//I_D1= k1*(V_GS1-V_T1)^2 and I_D2= k2*(2*(V_GS2-V_T2)*V_DS2-V_DS2^2)
// But V_GS2= Vi, V_DS2= Vo, V_GS1= V_DS1= V_DD-Vo
//Vo^2*(k1+k2)-Vo*[2*k1*(V_DD-V_T1)+2*k2*(Vi-V_T2)]+k1*(V_DD-V_T1)^2
A=(k1+k2);
B=-[2*k1*(V_DD-V_T1)+2*k2*(Vi-V_T2)];
C=k1*(V_DD-V_T1)^2;
Vo= [A B C]
Vo= roots(Vo);// in V
Vo= Vo(2);// in V
V_GS2= Vi;// in V
V_DS2= Vo;// in V
V_GS1= V_DD-Vo;// in V
I_D1= k1*(V_GS1-V_T1)^2;// in mA
I_D2= I_D1;// in mA
disp("Part (i) For Vi = 5 V")
disp(Vo,"The output voltage in volts is : ")
```

```
disp(I_D1,"The value of I_D1 in mA is : ")
disp(I_D2,"The value of I_D2 in mA is : ")
// Analysis for Vi= 1.5V
Vi= 1.5;// in V
//I_D2= k2*(V_GS2-V_T2)^2 and I_D1= k1*(V_GS1-V_T1)
    ^2
// But V_GS2= Vi, V_DS2= Vo, V_GS1= V_DS1= V_DD-Vo
//k2*(Vi-V_T2)^2= k1*(V_DD-Vo-V_T1)^2 or
Vo= V_DD-V_T1-sqrt(k2/k1)*(Vi-V_T2);// in V
I_D2= k2*(Vi-V_T2)^2;//in mA
I_D1= I_D2;// in mA
disp("Part (ii) For Vi = 1.5 V")
disp(Vo,"The output voltage in volts is : ")
disp(I_D1,"The value of I_D1 in mA is : ")
disp(I_D2,"The value of I_D2 in mA is : ")
```

Scilab code Exa 9.17 Value of ID and VDS

```
// Exa 9.17
clc;
clear;
close;
// Given data
k = 0.12;// in mA/V^2
V_T = -2.5;// in V
V_GS = 0;
I_D = k*((V_GS-V_T)^2);// in mA
disp(I_D,"The value of I_D in mA is");
V_DD = 6;// in V
R_S = 4.7;// in k ohm
V_DS = V_DD -(I_D*R_S);// in V
disp(V_DS,"The value of V_DS in V is ");
V_S = 0;// in V
V_DSsat = V_S - V_T;// in V
disp(V_DSsat,"The value of V_DS(sat) in V is");
```

```
if V_DS<V_DSsat then
    disp("The device is in the non saturation region
       ")
end
```

Scilab code Exa 9.18 Various voltage and current

```
// Exa 9.18
clc;
clear;
close;
// Given data
k4 = 0.125;// in mA/V^2
k3 = k4;// in mA/V^2
k2 = k4;// in mA/V^2
k1 = 0.25;// in mA/V^2
V_T1 = 0.8;// in V
V_T2 = V_T1;// in V
V_T3 = V_T1;// in V
V_T4 = V_T1;// in V
V_SS = -5;// in V
V_DD = 5;// in V
R_D = 10;// in k ohm
V_GS3 = ((sqrt(k4/k3) * (-V_SS - V_T4))+V_T3)/(1+
    sqrt(k4/k3));// in V
I_Q = k2*((V_GS3-V_T2)^2);// in mA
I_D1 = I_Q;// in mA
V_GS1 = V_T1 + (sqrt(I_D1/k1));// in V
disp(V_GS1,"The value of V_GS1 in V is");
V_DS2 = (-V_SS-V_GS1);// in V
disp(V_DS2,"The value of V_DS2 in V is");
V_DS1 = V_DD - (I_Q*R_D) - (V_SS + V_DS2);// in V
disp(V_DS1,"The value of V_DS1 in V is");
```

Scilab code Exa 9.19 Q point values

```
// Exa 9.19
clc;
clear;
close;
// Given data
R2 = 20;// in  k ohm
R1 = 30;// in  k ohm
R_D = 20;// in  k ohm
R_D=R_D*10^3;// in ohm
V_DD = 5;// in V
V_G = (R2/(R1+R2))*V_DD;// in V
V_S = 0;// in V
V_GS = V_G;// in V
k = 100*10^-6;// in A/V^2
V_T = 1;// in V
I_DQ = k*((V_GS-V_T)^2);// in A
disp(I_DQ * 10^6,"The value of I_DQ in  A is");
//R_D =R_D * 140^3;// in ohm
V_DSQ = V_DD - (I_DQ*R_D);// in V
disp(V_DSQ,"The value of V_DSQ in V is");
```

Scilab code Exa 9.20 IDQ VGSQ and VD

```
// Exa 9.20
clc;
clear;
close;
// Given data
V_P= -8;// in V
R_S= 2.4;// in  k
```

```
//R_D= 1800;// in
I_DSS= 8;// in mA
V_DD= 20;// in V
R_D= 6.2;// in k
// V_GS= -I_D*R_S
// I_D= I_DSS*(1-V_GS/V_P)^2 or I_DSS*(1-(-I_D*R_S)/
    V_P)^2
//I_D^2*R_S^2+I_D*(2*R_S*(V_P-V_G)-V_P^2/I_DSS)+(V_P
    )^2
A= R_S^2
B=(2*R_S*(V_P)-V_P^2/I_DSS)
C=(V_P)^2
I_D= [A B C]
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
I_DQ= I_D;// in mA
disp(I_DQ,"The value of I_DQ in mA is : ")
V_GSQ= -I_D*R_S;
disp(V_GSQ,"The value of V_GSQ in volts ")
V_D= V_DD-I_D*R_D;// in V
disp(V_D,"The value of V_D in volts is : ")
```

Scilab code Exa 9.21 ID VD VS and VG

```
// Exa 9.21
clc;
clear;
close;
// Given data
k= 75*10^-3;//in mA/V^2
Vth= -0.8;// in V
R2 = 100;// in k ohm
R1 = 100;// in  k ohm
R_S= 6;// in  k
R_D= 3;// in  k
```

```
V_SS = 10;// in V
V_G = (R2/(R1+R2))*V_SS;// in V
I_D= poly(0,'I_D');
V_S= V_SS-I_D*R_S;// in V
V_GS= V_G-V_S;//in V
I_D= I_D-k*(V_GS-Vth)^2;
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
V_DS= -V_SS+I_D*(R_D+R_S);// in V
V_D= I_D*R_D;// in V
V_S= I_D*R_S;// in V
disp(I_D,"The value of I_D in mA is : ")
disp(V_DS,"The value of V_DS in volts is : ")
disp(V_D,"The value of V_D in volts is : ")
disp(V_S,"The value of V_S in volts is : ")
```

Scilab code Exa 9.22 Value of RD

```
// Exa 9.22
clc;
clear;
close;
// Given data
V_T = 1;// in V
k = 160*10^-6;// in A/V^2
I_DQ = 160*10^-6;// in A
V_GS = V_T + sqrt(I_DQ/k);// in V
V_DD = 5;// in V
V_DSQ = 3;// in V
R_D = (V_DD - V_DSQ)/(I_DQ);// in ohm
R_D = R_D * 10^-3;// in k ohm
disp(R_D,"The value of R_D in k ohm is");
```

Scilab code Exa 9.23 Coordinates of operating point

```
// Exa 9.23
clc;
clear;
close;
// Given data
V_DD= 12;// in V
V_T= 2;// in V
kn= 0.5;// in mA/V^2
R1 = 2.2;// in M ohm
R2 = 1.8;// in M ohm
R_S= 1.5;// in  k
R_D= 3.9;// in  k
V_G = (R2/(R1+R2))*V_DD;// in V
I_D= poly(0,'I_D')
V_GS= V_G-I_D*R_S;// V
I_D= I_D-kn*(V_GS-V_T)^2;// in mA
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
I_DQ= I_D;// in mA
V_DSQ= V_DD-I_D*(R_D+R_S);// in V
disp(I_DQ,"The value of I_DQ in mA is : ")
disp(V_DSQ,"The value of V_DSQ in volts is : ")
V_GS= V_G-I_D*R_S;// V
V_DSsat= V_GS-V_T;// in V
disp("The value of  V_DS ( "+string(V_DSQ)+" V ) is
    greater than the value of ")
disp("V_DSsat ( "+string(V_DSsat)+" V ), So the
    MOSFET is in saturation region")
```

Scilab code Exa 9.24 IDSQ VGSQ and VDSQ

```
// Exa 9.24
clc;
```

```
clear;
close;
// Given data
kn= 0.5;// in mA/V^2
V_T= 1;// in V
R2 = 40;// in k ohm
R1 = 60;// in k ohm
R_S= 1;// in k ohm
R_D= 2;// in k ohm
V_DD = 5;// in V
V_SS = -5;// in V
V_R2 = (R2/(R2+R1))*(V_DD-V_SS);// in V
V_G = V_R2 - V_DD;// in V
I_D= poly(0,'I_D');
V_S= I_D*R_S+V_SS;// in V
V_GS= V_G-V_S;// in V
I_D=I_D-kn*(V_GS-V_T)^2;// in mA
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
I_DQ= I_D;// in mA
V_S= I_D*R_S+V_SS;// in V
V_GS= V_G-V_S;// in V
V_DSQ= V_DD-V_SS-I_D*(R_D+R_S);// in V
disp(I_DQ,"The value of I_DQ in mA is : ")
disp(V_GS,"The value of V_GS in volts is : ")
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 9.25 ID VDS VGS and Av

```
// Exa 9.25
clc;
clear;
close;
// Given data
R_S1 = 100*10^-3;// in k ohm
```

```
R_S2 = 100*10^-3;// in k ohm
R_S = R_S1+R_S2;// in k ohm
R_D= 1.8;// in k ohm
I_DSS= 12;// in mA
Vp= -3.5;// in V
V_DD= 22;// in V
rd= 25;// in k ohm
R_L= 47;// in k ohm
I_D= poly(0,'I_D');
V_GS= -I_D*R_S;// in V
I_D= I_D-I_DSS*(1-V_GS/Vp)^2;// in mA
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
disp(I_D,"The value of I_D in mA is : ")
V_GS= -I_D*R_S;// in V
disp(V_GS,"The value of V_GS in volts is : ")
V_DS= V_DD-I_D*(R_D+R_S);// in V
disp(V_DS,"The value of V_DS in volts is : ")
gmo= -2*I_DSS/Vp;// in mS
gm= gmo*(1-V_GS/Vp);// in mS
miu= gm*rd;
Av= -miu*R_D*R_L/(R_D+R_L)/(rd+R_D*R_L/(R_D+R_L)+(1+
   miu)*R_S1);
disp(Av,"The value of Av is : ")
```

Scilab code Exa 9.26 VGS ID and VDS

```
// Exa 9.26
clc;
clear;
close;
// Given data
V_T = 1;// in V
k = 0.5;// in mA/V^2
R2 = 40;// in k ohm
```

```
R1 = 60;// in k ohm
R_S= 1;// in k ohm
R_D= 2;// in k ohm
V_DD = 5;// in V
V_G = (R2/(R2+R1))*V_DD;// in V
I_D= poly(0,'I_D');
V_GS= V_G-I_D*R_S;// in V
I_D= I_D-k*(V_GS-V_T)^2;
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
V_GS= V_G-I_D*R_S;// in V
V_DS= V_DD-I_D*(R_D+R_S);// in V
disp(I_D,"The value of I_D in mA is : ")
disp(V_GS,"The value of V_GS in volts is : ")
disp(V_DS,"The value of V_DS in volts is : ")
```

Scilab code Exa 9.27 Drain current and source to drain voltage

```
// Exa 9.27
clc;
clear;
close;
// Given data
R_D = 7.5;// in k ohm
V_T = -0.8;// in V
k = 0.2;// in mA/V^2
R2 = 50;// in ohm
R1 = 50;// in  ohm
V_DD = 5;// in V
V_S = 5;// in V
V_G = (R2/(R2+R1))*V_DD;// in V
V_GS = V_G - V_S;// in V
I_D = k*((V_GS-V_T)^2);// in mA
disp(I_D,"Drain current in mA is");
V_SD = V_DD - (I_D*R_D);// in V
```

```
disp(V_SD,"Source to drain voltage in V is");
```

Scilab code Exa 9.28 IDQ VGSQ VD and VS

```
// Exa 9.28
clc;
clear;
close;
// Given data
I_Don = 5*10^-3;// in A
V_GSon = 6;// in V
V_GSth = 3;// in V
k = I_Don/(V_GSon-V_GSth)^2;// in A/V^2
R2 = 6.8;// in M ohm
R1 = 10;// in M ohm
R_S= 750;// in ohm
R_D= 2.2*10^3;// in ohm
V_DD = 24;// in V
R_S = 750;// in  ohm
V_G= R2*V_DD/(R1+R2);// in V
I_D= poly(0,'I_D');
V_GS= V_G-I_D*R_S;// in V
I_D= I_D-k*(V_GS-V_GSth)^2;
I_D= roots(I_D);// in A
I_D= I_D(2);// in A
I_DQ= I_D;// in A
V_GS= V_G-I_D*R_S;// in V
V_GSQ= V_GS;// in V
V_DSQ= V_DD-I_DQ*(R_D+R_S);// in V
disp(I_D*10^3,"The value of I_D in mA is : ")
disp(V_GSQ,"The value of V_GSQ in volts is : ")
disp(V_DSQ,"The value of V_DSQ in volts is : ")
```

Scilab code Exa 9.29 VDD RD and VGS

```
// Exa 9.29
clc;
clear;
close;
// Given data
I_Don = 4*10^-3;// in A
V_GSon = 6;// in V
V_GSth = 3;// in V
V_DS= 6;// in V
I_D= I_Don;// in A
k = I_Don/((V_GSon-V_GSth)^2);// in A/V^2
V_GS= poly(0,'V_GS')
V_GS= I_D-k*(V_GS-V_GSth)^2;
V_GS= roots(V_GS);// in V
V_GS= V_GS(1);// in V
V_DD= 2*V_DS;// in V
// V_GS= V_DD-I_D*R_D
R_D= (V_DD-V_GS)/I_D;// in ohm
disp(V_GS,"The value of V_GS in volts is : ")
disp(V_DD,"The value of V_DD in volts is : ")
disp(R_D*10^-3,"The value of R_D in k  is : ")
```

Scilab code Exa 9.30 ID VDS VG VS

```
// Exa 9.30
clc;
clear;
close;
// Given data
I_DD= 20;// in mA
R2 = 10;// in k ohm
R1 = 30;// in k ohm
R_S= 1.2;// in k ohm
```

```
R_D= 500*10^-3;// in k ohm
V_DD = 12;// in V
Vp= -6;// in V
V_G = (R2/(R2+R1))*V_DD;// in V
I_D= poly(0,'I_D')
V_GS= V_G-I_D*R_S;// in V
I_D=I_D-I_DD*(1-V_GS/Vp)^2;
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
V_DS= V_DD-I_D*(R_D+R_S);// in V
V_D= V_DD-I_D*R_D;// in V
V_S= V_D-V_DS;// in V
disp(I_D,"The value of I_D in mA is : ")
disp(V_DS,"The value of V_DS in volts is : ")
disp(V_D,"The value of V_D in volts is : ")
disp(V_S,"The value of V_S in volts is : ")
```

Scilab code Exa 9.31 Voltage at all nodes and currents through all branches

```
// Exa 9.31
clc;
clear;
close;
// Given data
V_DD = 5;// in V
V_T= 1;// in V
k= 1;// in mA/V^2
R1 = 1;// in M ohm
R2 = 1;// in M ohm
R_S= 2;// in k ohm
R_D= 2;// in k ohm
I1 = V_DD/(R1+R2);// in A
disp(I1,"The value of I1 in  A is : ")
V_A = (R2/(R2+R1))*V_DD;// in V
disp(V_A,"The value of V_A and V_G in volts is : ")
```

```
I_D= poly(0,'I_D');
V_C= I_D*R_S;// in V
V_GS= V_A-V_C;// in V
I_D= I_D-k*(V_GS-V_T)^2;
I_D= roots(I_D);// in mA
I_D= I_D(2);// in mA
disp(I_D,"The value of I_D in mA is : ")
V_B= V_DD-I_D*R_D;// in V
V_C= I_D*R_S;// in V
V_DS= V_B-V_C;// in V
disp(V_B,"The value of V_B in volts is : ")
disp(V_C,"The value of V_C in volts is : ")
disp(V_DS,"The value of V_DS in volts is : ")

// Note: In the book, the calculated values are
   wrong, this is why the answer in the book is
   wrong.
```

Scilab code Exa 9.32 Value of Av Ri and Ro

```
// Exa 9.32
clc;
clear;
close;
// Given data
I_DSS = 12;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P = -3;// in V
r_d = 45;// in k ohm
r_d= r_d*10^3;// in ohm
g_m = I_DSS/abs(V_P);// in S
// Part (i)
R1 = 91;// in M ohm
R1=R1*10^6;//in ohm
R2 = 10;// in M ohm
```

```
R2= R2*10^6;// in ohm
Ri= R1*R2/(R1+R2);// in ohm
disp(Ri*10^-6,"The value of Ri in Mohm is : ")
// Part (ii)
R_S = 1.1;// in k ohm
R_S = R_S * 10^3;// in ohm
R_o= (R_S*1/g_m)/(R_S+1/g_m);// in ohm
disp(R_o,"The value of R_C in ohm is : ")
// Part (iii)
R_desh_o= R_o*r_d/(R_o+r_d);// in ohm
disp(R_desh_o,"The value of R_desh_o in ohm is : ");
// Part (iv)
Av= g_m*(R_S*r_d/(R_S+r_d))/(1+g_m*(R_S*r_d/(R_S+r_d
    )));
disp(Av,"The value of Av is : ")
```

Scilab code Exa 9.34 Current flow through M1 MOSFET

```
// Exa 9.34
clc;
clear;
close;
// Given data
V_S2 = -2;// in V
V_GS2 = -V_S2;// in V
I_DS2 = (V_GS2-1)^2;// in mA
I = 2;// in mA
I_DS1 = I-I_DS2;// in mA
disp(I_DS1,"The current flow through M1 MOSFET in mA
    is");
```

Scilab code Exa 9.35 Value of R and VD

```
// Exa 9.35
clc;
clear;
close;
// Given data
V_DD= 10;// in V
I_D= 0.4*10^3;// in A
W= 100;// in  m
L= 10;// in  m
uACox= 20;// in A/V^2
Vt= 2;// in V
R= poly(0,'R')
V_GS= V_DD-I_D*R;// in V
R= I_D-1/2*uACox*W/L*(V_GS-Vt)^2;
R= roots(R);// in Mohm
R= R(2);// in Mohm
disp(R*10^3,"The value of R in k  is : ")
V_D= V_DD-I_D*R;// in V
disp(V_D,"The value of V_D in volts is : ")
```

Scilab code Exa 9.36 ID and VDS

```
// Exa 9.36
clc;
clear;
close;
// Given data
V_GSth= 2;// in V
k= 2*10^-4;// in A/V^2
V_DD= 12;// in V
R_D= 5*10^3;// in ohm
I_D= poly(0,'I_D');
V_DS= V_DD-I_D*R_D;// in V
I_D= I_D-k*(V_DS-V_GSth)^2;
I_D= roots(I_D);// in A
```

```
I_D= I_D(2);// in A
V_DS= V_DD-I_D*R_D;// in V
disp(I_D*10^3,"The value of I_D in mA is : ")
disp(V_DS,"The value of V_DS in volts is : ")
```