Scilab Textbook Companion for Fundamentals Of Electronic Devices by J. B. Gupta[1]

Created by
Mohd. Arif
B.Tech
Computer Engineering
Uttarakhand Tech. university
College Teacher
Arshad Khan
Cross-Checked by
Lavitha Pereira

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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 crystal properties

Scilab code Exa 1.3 Calculate Density of Copper Crystal

```
//Exa 1.3
clc;
clear;
close;
//given data
r=1.278;//in Angstrum
AtomicWeight=63.5;//constant
AvogadroNo=6.023*10^23;//constant
//For FCC structure a=4*r/sqrt(2)
a=4*r*10^-10/sqrt(2);//in meter
V=a^3;//in meter^3
//mass of one atom = m
m=AtomicWeight/AvogadroNo;//in gm
m=m/1000;//in Kg
n=4;// no. of atoms per unit cell for FCC structure
rho=m*n/V;//in Kg/m^3
disp(rho,"Density of crystal in Kg/m^3: ");
```

Scilab code Exa 1.4 Obtain volume density of Si atoms

```
//Exa 1.4
clc;
clear;
close;
//given data
n=4;// no. of atoms per unit cell of silicon
AtomicWeight=28;//constant
AvogadroNo=6.021*10^23;//constant
m=AtomicWeight/AvogadroNo;//in gm
m=m/1000;//in Kg
a=5.3;//lattice constant in Angstrum
a=a*10^-10;//in meter
V=a^3;//in meter^3
rho=m*n/V;//in Kg/m^3
disp(rho,"Density of silicon crystal in Kg/m^3: ");
```

Scilab code Exa 1.5 Calculate surface density of atoms

```
//Exa 1.5
clc;
clear;
close;
//given data
a=4.75;//lattice constant in Angstrum
a=a*10^-10;//in meter
disp("Surface density in FCC on (111)Plane : dp =
    2.31/a^2");
dp=2.31/a^2;//in atom/m^2
dp=dp/10^6;//in atom/mm^2
```

```
disp(dp,"Surface density in FCC on (111)Plane in
   atoms/mm^2: ");
```

Scilab code Exa 1.6 Determine Interplanar Distance

```
//Exa 1.6
clc;
clear;
close;
//given data
lambda=1.539;//in Angstrum
theta=22.5;//in degree
n=1;//order unitless
d=n*lambda/(2*sin(theta*%pi/180));//in Angstrum
disp(d,"Interpolar distance in Angstrum : ")
```

Scilab code Exa 1.7 Determine Wavelength of X rays

```
//Exa 1.7
clc;
clear;
close;
//given data

theta=16.8/2;//in degree
n=2;//order unitless
d=0.4;//in nm
lambda=(2*d*sin(theta*%pi/180))/n;//in Angstrum
disp(lambda,"wavelength of X-rays in Angstrum : ");
//Note: Ans in the book is not correct
```

Chapter 2

Energy Bands and Charge Carriers in Semiconductor

Scilab code Exa 2.1 Calculate the velocity of electron at fermi level

```
//Exa 2.1
clc;
clear;
close;
//given data
E=2.1;//in eV
E=E*1.602*10^-19;//in Joule
m=9.107*10^-31;//in Kg
//Formula : E= (m*v^2)/2
v=sqrt(2*E/m);//in m/s
disp(v,"Velocity of electron at fermi level in m/s :
    ");
```

Scilab code Exa 2.2 Determine Drift Velocity of Electrons

```
//Exa 2.2
```

```
clc;
clear;
close;
//given data
J=2.4;//in A/mm^2
J=J*10^6;//in A/m^2
n=5*10^28;//electrons/m^3
e=1.6*10^-19;//constant
//Formula : J=e*n*v
v=J/(e*n);//in m/s
disp(v*10^3,"Velocity of electron at fermi level in
    mm/s : ");
```

Scilab code Exa 2.3 Calculate magnitude of currrent

```
//Exa 2.3
clc;
clear;
close;
//given data
n=10^24;//electrons/m^3
e=1.6*10^-19;//constant
v=1.5*10^-2;//in m/s
A=1;//in cm^2
A=1*10^-4;//in m^2
I=e*n*v*A;//in Ampere
disp(I,"Magnitude of current in Ampere : ");
```

Scilab code Exa 2.4 Find electron and hole densities

```
//Exa 2.4
clc;
clear;
```

```
close;
//given data
ni=2.5*10^13;//in atoms/cm^3
rho=0.039;//in ohm-cm
SIGMAn=1/rho;//in (ohm-cm)^-1
e=1.6*10^-19;//constant
MUe=3600;//in cm^2/V-s
//formula : SIGMAn=n*e*MUe=Nd*e*MUe
Nd=SIGMAn/(e*MUe);//in atoms/cm^3
n=Nd;//in atoms/cm^3
p=ni^2/n;//in atoms/cm^3
disp(n,"Electron density in atoms/cm^3 : ");
disp(p,"Hole density in atoms/cm^3 : ");
```

Scilab code Exa 2.5 Calculate concentrations in semiconductor

```
//Exa 2.5
clc;
clear;
close;
//given data
DonorImpurity=1/10^6;;//impurity per atom
SiAtomCon=5*10^22;//in cm^-3
ni=1.45*10^10;//in cm^-3
MUe=1300;//in cm^2/V-s
e=1.6*10^-19;//constant
//part (i)
Nd=SiAtomCon*DonorImpurity;//in cm^-3
disp(Nd,"Donor atom concentration in cm^-3 : ");
//part (ii)
n=Nd;//in cm^-3
disp(n,"Mobile electron concentration in cm^-3: ");
//part (iii)
p=ni^2/Nd;//in cm^-3
disp(p,"Hole concentration in cm^-3 : ");
```

```
//part (iv)
SIGMA=n*e*MUe;//in (ohm-cm)^-1
disp(SIGMA,"Conductivity of doped silicon sample in
    (ohm-cm)^-1 : ");
//part (v)
rho=1/SIGMA;//in ohm-cm
l=0.5;//in cm
A=(50*10^-4)^2;//in cm^2
R=rho*l/A;//in ohm
disp(rho,"Resistivity in ohm-cm : ");
disp(R,"Resistance in ohm : ")
```

Scilab code Exa 2.6 Find ratio of electron to hole concentration

```
//Exa 2.6
clc;
clear;
close;
//given data
ni=1.4*10^18;//in atoms/m^3
Nd=1.4*10^24;//in atoms/m^3
n=Nd;//in atoms/m^3
p=ni^2/n;//in atoms/m^3
ratio=n/p;//unitless
disp(p,"Concentration of holes in per m^3 : ");
disp(ratio,"Ratio of electron to hole concentration
    : ");
```

Scilab code Exa 2.7 Calculate relaxation time resistivity and velocity of electron

```
//Exa 2.7
clc;
```

```
clear;
close;
//given data
Ef=5.5;//in eV
MUe=7.04*10^-3;//in m^2/V-s
n=5.8*10^28;//in m^-3
e=1.6*10^-19;//constant
m=9.1*10^-31;//in Kg
//part (i)
tau=MUe*m/e;//in sec
disp(tau,"Relaxation time in sec : ");
rho=1/(n*e*MUe);//in ohm-m
disp(rho,"Resistivity of conductor in ohm-m : ")
vF=sqrt(2*Ef*1.6*10^-19/m);
disp(vF,"velocity of electron with fermi energy in m
    /s : ");
```

Scilab code Exa 2.8 Find conductivity and resistivity

```
//Exa 2.8
clc;
clear;
close;
//given data
ni=2.5*10^13;//in cm^-3
e=1.6*10^-19;//in coulamb
MUh=1800;//in cm^2/V-s
MUe=3800;//in cm^2/V-s
SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
RHOi=1/SIGMAi;//in ohm-cm
disp(SIGMAi,"Intrinsic conductivity in (ohm-cm)^-1 :
    ");
disp(RHOi,"Intrinsic resistivity in ohm-cm : ");
```

Scilab code Exa 2.9 Calculate density of electron

```
//Exa 2.9
clc;
clear;
close;
//given data
SIGMAi=2.12766;//in S/m
RHOi=0.47;//in ohm-m
MUh=0.19;//in m^2/V-s
MUe=0.39;//in m^2/V-s
e=1.6*10^-19;//in coulamb
//Formula : SIGMAi=ni*e*(MUe+MUh)
ni=SIGMAi/(e*(MUe+MUh));//in m^-3
E=10^4;//in V/m
vn=MUe*E;//in m/s
vh=MUh*E;//in m/s
disp(ni,"Density of electron in intrinsic material
   in m^-3 : ");
disp(vn,"Drift velocity for electrons in m/s : ");
disp(vh,"Drift velocity for holes in m/s : ");
```

Scilab code Exa 2.10 Find conductivity of Si

```
//Exa 2.10
clc;
clear;
close;
//given data
ni=1.5*10^10;//in cm^-3
e=1.6*10^-19;//in coulamb
MUh=450;//in cm^2/V-s
```

```
MUe=1300;//in cm^2/V-s
SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
disp(SIGMAi,"Conductivity of silicon(intrinsic) in (ohm-cm)^-1 ");
Na=10^18;//in cm^-1
SIGMAp=e*Na*MUh;//in (ohm-cm)^-1
disp(SIGMAp,"Conductivity of resulting P-type si semiconductor in (ohm-cm)^-1 : ");
```

Scilab code Exa 2.11 Find conductivity of intrinsic Ge

```
//Exa 2.11
clc;
clear;
close;
//given data
ni=2.5*10^13;//in cm^-3
e=1.6*10^-19;//in coulamb
MUh=1800;//in cm^2/V-s
MUe=3800;//in cm^2/V-s
SIGMAi=ni*e*(MUe+MUh);//in (ohm-cm)^-1
GeAtoms=4.41*10^22;//in cm^-1
DonorImpurity=1/10^7;//in per Ge Atom
Nd=4.41*10^22*DonorImpurity;//in cm^-1
n=Nd;//in cm^-1
p=ni^2/Nd;//in cm^-3
SIGMAn=e*Nd*MUe;//in (ohm-cm)^-1
disp(SIGMAi,"Conductivity of Ge(intrinsic) in (ohm-cm)^-1 ");
disp(SIGMAn,"Conductivity of resulting N-type Ge semiconductor in (ohm-cm)^-1 : ");
```

Scilab code Exa 2.12 Find drift velocity of electron and hole Conductivity and current

```
//Exa 2.12
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
MUh=0.18;//in m^2/V-s
MUe=0.38;//in m^2/V-s
V=10;//in Volts
l=25;//in mm
w=4;//in mm
t=1.5;//in mm
E=V/(l*10^-3);//in
//part (i)
ve=MUe*E;//in m/s
vh=MUh*E;//in m/s
disp(ve,"Drift velocity for electrons in m/s : ");
disp(vh,"Drift velocity for holes in m/s : ");

ni=2.5*10^19;//in m^-3
//part (ii)
SIGMAi=ni*e*(MUe+MUh);//in (ohm-m)^-1
disp(SIGMAi,"Conductivity of Ge(intrinsic) in (ohm-m
    )^-1 ");
//part (iii)
I=SIGMAi*E*w*10^-3*t*10^-3;//in Ampere
disp(I*10^3,"Total current in mili ampere : ");
```

Scilab code Exa 2.13 Find diffusion coefficient of electron and hole

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

```
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
T=300;//in Kelvin
MUh=1700;//in cm^2/V-s
MUe=3600;//in cm^2/V-s
k=1.38*10^-23;//in J/K
De=MUe*k*T/e;//in cm^2/s
Dh=MUh*k*T/e;//in cm^2/s
disp(De,"Diffusion constant of electron(in cm^2/s) :
    ");
disp(Dh,"Diffusion constant of hole(in cm^2/s) : ");
```

Scilab code Exa 2.14 Find mobility and density of charge carriers

```
//Exa 2.14
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
resistivity=9*10^-3;//in ohm-m
RH=3.6*10^-4;//in m^3-coulamb^-1
SIGMA=1/resistivity;//in (ohm-m)^-1
rho=1/RH;//in cooulamb/m^3
n=rho/e;//in m^-3
disp(n,"Density of charge carriers in m^-3 : ");
MU=SIGMA*RH;//in m^2/V-s
disp(MU,"Mobility in m^2/V-s : ");
```

Scilab code Exa 2.15 Determine current density

```
//Exa 2.15
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
E=100;//in V/m
RH=0.0145;//in m^3-coulamb^-1
MUn=0.36;//in m^2/V-s
J=MUn*E/RH;//in A/m^2
disp(J,"Current density in A/m^2 : ");
```

Scilab code Exa 2.16 Calculate Hall coefficients

```
//Exa 2.16
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
n=2.05*10^22;//in m^-3
RH=1/(n*e);//in m^3-coulamb^-1
disp(RH,"Hall coefficient in m^3-coulamb^-1 : ");
```

Scilab code Exa 2.17 Find magnitude of hall voltage

```
//Exa 2.17
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
ND=10^17;//in cm^-3
```

```
Bz=0.1;//in Wb/m^2
w=4;//in mm
d=4;//in mm
Ex=5;//in V/cm
MUe=3800;//in cm^2/V-s
v=MUe*Ex;//in cm/s
v=v*10^-2;//in m/s
VH=Bz*v*d;//in mV
disp(VH,"Magnitude of hall voltage in mV : ");
```

Scilab code Exa 2.18 Determine mobility of holes

```
//Exa 2.18
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
w=3;//in mm
d=3;//in mm
rho=200;//in Kohm-cm
rho=rho*10^3*10^-2;//in ohm-m
VH=50;//in mV
VH=VH*10^-3;//in Volts
I=10;//in uA
I=I*10^-6;//in Ampere
Bz=0.1;//in Wb/m^2
RH=VH*w*10^-3/(Bz*I)
MUh=RH/rho;//in m^2/V-s
disp(MUh,"Mobility of holes in p-type Si bar in m^2/
    V-s : ");
```

Scilab code Exa 2.19 Determine Hall Voltage

```
//Exa 2.19
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
ND=10^21;//in m^-3
Bz=0.2;//in T
d=4;//in mm
d=d*10^-3;//in meter
J=600;//in A/m^2
n=ND;//in m^-3
//formula : VH*w/(B*I)=1/(n*e)
VH=Bz*J*d/(n*e);//in V
disp(VH*10^3,"Magnitude of hall voltage in mV : ");
```

Scilab code Exa 2.20 Calculate Hall angle

```
//Exa 2.20
clc;
clear;
close;
//given data
e=1.6*10^-19;//in coulamb
rho=0.00912;//in ohm-m
B=0.48;//in Wb/m^2
RH=3.55*10^-4;//in m^3-coulamb^-1
SIGMA=1/rho;//in (ohm-m)^-1
THETAh=atand(SIGMA*B*RH);//in Degree
disp(THETAh,"Hall angle in degree : ");
```

Chapter 3

Excess Carriers in Semiconductors

Scilab code Exa 3.2 Find minimum Energy

```
//Exa 3.2
clc;
clear;
close;
//given data
lambda=6000;//in Angstrum
h=6.6*10^(-34);//Planks constant
c=3*10^8;//speed of light in m/s
e=1.602*10^(-19);//Constant
phi=c*h/(e*lambda*10^(-10));
disp(phi,"Minimum required energy in eV is :");
//Note : Ans in the book is n ot correct
```

Scilab code Exa 3.3 Calculate work function

```
//Exa 3.3
```

```
clc;
clear;
close;
//given data
Emax=2.5;//maximum energy of emitted electrons in eV
lambda=2537;//in Angstrum
EeV=12400/lambda;//in eV
disp(EeV,"The eV equivalent of the energy of
    incident photon : ");
phi=EeV-Emax;//in eV
disp(phi,"Work function of the cathode material is "
    );
```

Scilab code Exa 3.4 Determine power absorbed and rate of excess thermal energy

```
//Exa 3.4
clc;
clear;
close;
//given data
t=0.46*10^-6;//in meters
hf=2;//in ev
Pin=10;//in mW
alpha=50000;// in per cm
e=1.6*10^-19;//constant
Io=10^-2;//in mW
It=Io*e^(-alpha*t);//in mW
//Part (i)
disp("Thus power absorbed = 10-1 = 9 mW or 0.009 J/s
    ");
disp((2-1.43)/2,"The fraction of each photon energy
    unit which is converted into heat");
//Part (ii)
disp(((2-1.43)/2)*0.009,"Energy converted into heat
```

```
in J/s:");
//Part (iii)
disp(0.009/(e*2),"Number of photons per second given
  off from recombination events :");
```

Scilab code Exa 3.5 Determine electron transit time and photoconductor gain

```
//Exa 3.5
clc;
clear;
close;
//given data
L=100;//in uM
A=10&-7;//in cm^2
th=10^-6;//in sec
V=12;//in Volts
ue=0.13;//in m^2/V-s
uh=0.05;//in m^2/V-s
E=V/(L*10^-6);//in V/m
tn=(L*10^-6)/(ue*E);
disp(tn,"Electron transit time in sec is ");
Gain=(1+uh/ue)*(th/tn);
disp(Gain,"Photoconductor gain is ");
```

Scilab code Exa 3.6 Determine current through diode

```
//Exa 3.6
clc;
clear;
close;
//given datex
Io=0.15;//in uA
```

```
V=0.12;//in mVolt
Vt=26;//in mVolt
I=Io*10^-6*(exp(V/(Vt*10^-3))-1);//in A
disp(I*10^6,"Current flowing through diode in uA is
    ");
```

Scilab code Exa 3.7 Find forward voltage

```
//Exa 3.7
clc;
clear;
close;
//given data
Io=2.5;//in uA
I=10;//in mA
Vt=26;//in mVolt
n=2;//for silicon
V=n*Vt*10^-3*log((I*10^-3)/(Io*10^-6))
disp(V,"Forward voltage in volts is ");
```

Scilab code Exa 3.8 Find reverse saturation current density

```
//Exa 3.8
clc;
clear;
close;
//given data
ND=10^21;//in m^-3
NA=10^22;//in m^-3
De=3.4*10^-3;//in m^2-s^-1
Dh=1.2*10^-3;//in m^2-s^-1
Le=7.1*10^-4;//in meters
Lh=3.5*10^-4;//in meters
```

```
ni=1.6*10^16;//in m^-3
e=1.602*10^-19;//constant
IoA=e*ni^2*(Dh/(Lh*ND)+De/(Le*NA));
disp(IoA*10^6,"Reverse saturation current density in
    uA/m2 is ")
```

Chapter 4

Junction Properties

Scilab code Exa 4.2 Calculate electron and hole concentration at thermal equilibrium

```
//Exa4.2
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=10^16;//in cm^-3
NA=0;//in cm^-3
ni=1.5*10^10;//in cm^-3
no=ND/2+sqrt((ND/2)^2+ni^2);//in cm^-3
po=ni^2/no;//in cm^-3
disp(no,"Majority carrier electron concentration in
   cm^-3 : ");
disp(po,"Minority carrier hole concentration in cm
   ^-3 : ");
```

Scilab code Exa 4.3 Calculate electron and hole concentration at thermal equilibrium

```
//Exa4.3
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=3*10^15;//in cm^-3
NA=10^16;//in cm^-3
ni=1.6*10^10;//in cm^-3
po=(NA-ND)/2+sqrt(((NA-ND)/2)^2+ni^2);//in cm^-3
no=ni^2/po;//in cm^-3
disp(po,"Majority carrier hole concentration in cm
    ^-3 : ");
disp(no,"Minority carrier electron concentration in
    cm^-3 : ");
```

Scilab code Exa 4.4 determine built in potential barrier

```
//Exa4.4
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=10^15;//in cm^-3
NA=10^18;//in cm^-3
ni=1.5*10^10;//in cm^-3
VT=T/11600;//in Volts
Vbi=VT*log(NA*ND/ni^2);//in Volts
disp(Vbi,"Built in potential barrier in volts : ");
```

Scilab code Exa 4.5 Obtain value of contact potential

```
//Exa4.5
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=10^21;//in m^-3
NA=10^21;//in m^-3
ni=1.5*10^16;//in m^-3
VT=T/11600;//in Volts
Vo=VT*log(NA*ND/ni^2);//in Volts
disp(Vo,"Contact p;otential in volts : ");
```

Scilab code Exa 4.6 Determine space charge width and electric field

```
//Exa4.6
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=10^15;//in cm^-3
NA=10^16;//in cm^-3
ni=1.5*10^10;//in cm^-3
VT=T/11600;//in Volts
e=1.6*10^-19;//in Coulamb
epsilon=11.7*8.854*10^-14;//constant
Vbi=VT*log(NA*ND/ni^2);//in Volts
SCW=sqrt((2*epsilon*Vbi/e)*(NA+ND)/(NA*ND));//in cm
SCW=SCW*10^4;//in uMeter
disp(SCW,"Space charge width in uMeters : ");
xn=0.864;//in uM
xp=0.086;//in uM
Emax=-e*ND*xn/epsilon;//in V/cm
disp(Emax,"At metallurgical junction, i.e for x=0
```

```
the electric field is peak i.e. Emax in volts : "
);
//Note : Ans in the book is wrong
```

Scilab code Exa 4.7 Obtain value of contact potential

```
//Exa4.7
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=10^21;//in m^-3
NA=10^21;//in m^-3
ni=1.5*10^16;//in m^-3
VT=T/11600;//in Volts
Vo=VT*log(NA*ND/ni^2);//in Volts
disp(Vo,"Contact potential in volts : ");
```

Scilab code Exa 4.8 Calculate height of potential barrier

```
//Exa4.8
clc;
clear;
close;
//given data
T=300;//in Kelvin
ND=8*10^14;//in cm^-3
NA=8*10^14;//in cm^-3
ni=2*10^13;//in cm^-3
k=8.61*10^-5;//in eV/K
Vo=k*T*log(NA*ND/ni^2);//in Volts
disp(Vo,"Contact potential in volts : ");
```

Scilab code Exa 4.9 Find current in the circuit

```
//Exa4.9
clc;
clear;
close;
//In given circuit :
V=5;//in volts
Vo=0.7;//in Volts
R=100;//in Kohm
disp("Since diode is silicon one, and the barrier
   potential for Si diode is 0.7 volt, Vo = 0.7
   volts ");
disp("This barrier potential acts in opposite
   direction to the applied voltage. The diode
   forward resistance is being assumed to be zero.")
   ;
I=(V-Vo)/R;//in Ampere
disp(I*1000,"Current flowing through the circuit in
   Amperes :")
```

Scilab code Exa 4.10 Determine voltage VA in the circuit

```
//Exa4.10
clc;
clear;
close;
//In given circuit :
V=15;//in volts
Vo=0.7;//in Volts
R=7;//in Kohm
```

```
I=(V-2*Vo)/R
disp("Since diode is silicon one, and the barrier
   potential for Si diode is 0.7 volt, Vo = 0.7
   volts ");
disp("This barrier potential acts in opposite
   direction to the applied voltage. The diode
   forward resistance is being assumed to be zero.")
   ;
I=(V-2*Vo)/R;//in mAmpere
disp("Barrier potential of Si diode, Vo = 0.7 Volts"
   );
disp("Potential VA = Voltage drop across 7 Kohm
   resistor");
VA=I*R;//in Volts
disp(VA,"Voltagee VA in volts : ");
```

Scilab code Exa 4.12 Determine temperature coefficients

```
//Exa4.12
clc;
clear;
close;
//given data
Vz=5;//in volts
to=25;//in degree centigrade
t=100;//in degree centigrade
Vdrop=4.8;//in Volts
delVz=Vdrop-Vz;//in Volts
delt=t-to;//in degree centigrade
TempCoeff=delVz*100/(Vz*delt);
disp(TempCoeff,"Temperature coefficient f zener
   diode in % : ");
```

Scilab code Exa 4.13 Find output voltage and current through Zener diode

```
//Exa4.13
clc;
clear;
close;
//given data
Vz=8;//in volts
VS=12;//in volts
Vout=8;//in volts
RL=10;//in Kohm
Rs=5;//in Kohm
//part (a)
disp("Output voltage will be equal to Vz i.e "+
   string(Vz)+" Volts");
//part (b)
Vrs=VS-Vout;//in volts
disp(Vrs,"Voltage across Rs in volts : ");
IL=Vout/RL;//in mAmpere
Is=(VS-Vout)/Rs;//in mAmpere
Iz=Is-IL;//in mAmpere
disp(Iz,"Current through zener diode in mA : ");
```

Scilab code Exa 4.14 Find maximum and minimum values of zener diode current

```
//Exa4.14
clc;
clear;
close;
//given data
Vz=50;//in volts
VSmax=120;//in volts
VSmin=80;//in volts
RL=10;//in Kohm
```

```
Rs=5;//in Kohm
Vout=Vz;//in Volts
disp("Output voltage will be equal to Vz i.e "+string(Vz)+" Volts");
IL=Vout/RL;//in mAmpere
disp("The zener current will be maximum when input voltage is maximum i.e. 120V.");
ISmax=(VSmax-Vout)/Rs;//in mAmpere
Izmax=ISmax-IL;//in mA
disp(Izmax,"Maximum zener diode current in mA : ");
disp("The zener current will be minimum when input voltage is minimum i.e. 80V.");
Ismin=(VSmin-Vout)/Rs;//in mAmpere
Izmin=Ismin-IL;//in mA
disp(Izmin,"Minimum zener diode current in mA : ");
```

Scilab code Exa 4.15 Design a regulator

```
//Exa4.15
clc;
clear;
close;
//given data
Vz=15;//in volts
Izk=6;//in mA
Vout=15;//in Volts
Vs=20;//in Volts
ILmin=10;//in mA
ILmax=20;//in mA
disp("the zener current will be minimum i.e. Izk = 6 mA when load current is maximum i.e. ILmax = 20mA ");
RS=(Vs-Vout)/(Izk+ILmax);//in ohm
disp("when the load current will decrease and become 10 mA, the zener current will increase and
```

```
   become 6+10 i.e. 16 mA. Thus the current through
   series resistance Rs will remain unchanged at
   6+20 i.e. 26 mA. Thus voltage drop in series
   resistance Rs will remain constant. Consequently,
    the output voltage will also remain constant.")
   ;
```

Scilab code Exa 4.16 Determine VL IZ and PZ

```
//Exa4.16
clc;
clear;
close;
//given data
Vs=16;//in volts
RL=1.2;//in Kohm
Rs=1;//in Kohm
//If zener open circuited
VL=Vs*RL/(Rs+RL);//in Volts
disp(VL,"When zener open circuited Voltage across
   load in volts : ");
disp("Since voltage across load VL is less than
   breakdown voltage of zener diode i.e. VL < Vz.
   The zener diode will not conduct and VL = 8.73
   Volt");
Iz=0;//in mA
disp(Iz,"Zener current in mA : ");
Pz=VL*Iz;//in watts
disp(Pz,"Power in watts : ");
```

Scilab code Exa 4.17 Comment on operation of circuit

```
//Exa4.17
```

```
clc;
clear;
close;
//given data
Vin=20;//in volts
Rs=220;//in Kohm
Vz=10;//in volts
// part (i) RL=50;//in Kohm
disp("For RL=50ohm :");
RL=50;//in Kohm
VL=Vin*RL/(RL+Rs)
disp("Since voltage across load, VL is less than
    breakdown voltage of zener diode. Zener will not
    conduct.")
IR=Vin/(Rs+RL);//in mA
IL=IR;//in mA
IZ=0;//in mA
disp(VL,"VL in volt : ");
disp(IL*1000,"IL in mA :");
disp(IZ,"Iz in mA: ");
disp(IR*1000,"IR in mA :");

// part (ii) RL=200;//in Kohm
disp("For RL=200ohm : ")
RL=200;//in Kohm
VL=Vin*RL/(RL+Rs)
disp("voltage across load, if zener diode is open
    circuited.")
IR=Vin/(Rs+RL);//in mA
IL=IR;//in mA
IZ=0;//in mA
disp(VL,"VL in volt : ");
disp(IL*1000,"IL in mA :");
disp(IZ,"Iz in mA: ");
disp(IR*1000,"IR in mA :");
```

Scilab code Exa 4.18 Find voltage drop across the resistance

```
//Exa4.18
clc;
clear;
close;
//given data
RL=10;//in Kohm
Rs=5;//in Kohm
Vin=100;//in Volts
disp("Removing the zener diode from the circuit , We
   have : V = Vin*RL/(RL+Rs)");
V=Vin*RL/(RL+Rs);//in Volt
disp(V,"Voltage V in volts = ");
disp("V > Vz So zener diode is in ON stste.");
VZ=50;//in Volts
VL=VZ;//in volts
//Apply KVL
VR=100-50;//in Volts
VR=50;//in Volts
disp(VR,"Hence the voltage dropp across the 5 Kohm
   resistor in Volts is : ");
```

Scilab code Exa 4.19 Find Ri so that VL remain 12V

```
//Exa4.19
clc;
clear;
close;
//given data
RL=120;//in ohm
Izmin=20;//in mA
```

```
Izmax=200;//in mA
VL=12;//in Volts
VDCmin=15;//in Volts
VDCmax=19.5;//in Volts
Vz=12;//in Volts
IL=VL/RL;//in Ampere
IL=IL*1000;//in mAmpere
//For VDCmin = 15 volts
VSmin=VDCmin-Vz;//in Volts
//For VDCmax = 19.5 volts
VSmax=VDCmax-Vz;//in Volts
ISmin=Izmin+IL;//in mA
Ri=VSmin/ISmin;//in Kohm
Ri=Ri*10^3;//in ohm
disp(Ri,"The resistance Ri in ohm : ");
```

Scilab code Exa 4.20 Determine range of RL and IL

```
//Exa4.20
clc;
clear;
close;
//given data
VRL=10;//in Volts
Vi=50;//in Volts
R=1;//in Kohm
Vz=10;//in Volts
VL=Vz;//in Volts
Izm=32;//in mA
IR=(Vi-VL)/R;//in mA
disp("Load current IL will be maximum when Iz = 0 ")
    ;
Izmin=0;//in mA
ILmax=IR-Izmin;//in mA
disp(ILmax,"Maximum load current in mA : ");
```

```
RLmin=VL/ILmax;//in Ohm
disp("Load current IL will be minimum when Iz =
    maximum i.e. 32 mA ");
Izmax=32;//in mA
ILmin=IR-Izmax;//in mA
disp(ILmin,"Minimum load current in mA : ");
VL=Vz;//in Volts
RLmax=VL/ILmin;//in Ohm
disp("Hence range of RL and IL are as follows :");
disp("Range of RL in Kohm : From "+string(RLmin)+"
    to "+string(RLmax));
disp("Range of IL in mA : From "+string(ILmin)+" to
    "+string(ILmax));
```

Chapter 5

Junction Properties Continued

Scilab code Exa 5.1 Estimate junction width

```
//Exa 5.1
clc;
clear;
close;
//given data
ND=10^17;//in atoms/cm^3
NA=0.5*10^16;//in atoms/cm^3
Vo=0.7;//in Volts
V=-10;//in Volts
ND=ND*10^6;//in atoms/m^3
NA=NA*10^6;//in atoms/m^3
epsilon=8.85*10^-11;//in F/m
e=1.6*10^-19;//coulamb
//part (i)
disp("When no external voltage is applied i.e. V=0")
    ;
disp("VB = 0.7 volts");
VB=0.7;//in Volts
W=sqrt(2*epsilon*VB*(1/NA+1/ND)/e);//in m
disp(W,"When no external voltage is applied,
   Junction width in meter : ");
```

```
//part (ii)
disp("When external voltage of -10 volt is applied");
disp("VB = Vo-V volts");
VB=Vo-V;//in Volts
W=sqrt(2*epsilon*VB*(1/NA+1/ND)/e);//in m
disp(W,"When external voltage of -10 Volt is applied, Junction width in meter : ");
```

Scilab code Exa 5.3 Find new position of fermi level

```
//Exa 5.3
clc;
clear;
close;
//given data
Ecf=0.3;//in Volts
T=27+273;//in Kelvin
delT=55;//in degree centigrade
//formula : Ecf=Ec-Ef=K*T*log(nc/ND)
//let K*log(nc/ND)=y
//Ecf=Ec-Ef=T*y
y=Ecf/T;//assumed
Tnew=273+55;//in Kelvin
EcfNEW=y*Tnew;//in Volts
disp(EcfNEW,"New position of fermi level is(eV) : ");
```

Scilab code Exa 5.4 Calculate height of potential barrier

```
//Exa 5.4
clc;
clear;
```

```
close;
//given data
ND=8*10^14;//in cm^-3
NA=8*10^14;//in cm^-3
ni=2*10^13;//in cm^-3
T=300;//in Kelvin
k=8.61*10^-5;//in eV/K
e=1.6*10^-19;//coulamb
Vo=k*T*log(ND*NA/ni^2);//in Volts
disp(Vo,"Potential barrier in volts : ");
```

Scilab code Exa 5.5 Find electron and hole concentration

```
//Exa 5.5
clc;
clear;
close;
//given data
ND=2*10^16;//in cm^-3
NA=5*10^15;//in cm^-3
Ao=4.83*10^21;//constant
T=300;//in Kelvin
EG=1.1;//in eV
kT=0.026;//in eV
ni=Ao*T^(3/2)*exp(-EG/(2*kT));//in m^-3
ni=ni*10^-6;//in cm^-3
p=(ni^2)/ND;//in cm^-3
n=(ni^2)/NA;//in cm^-3
disp(p,"Hole concentration in cm^-3 : ");
disp(n,"electron concentration in cm^-3 : ");
disp("Since elctron concentration is mote than hole
    concentration, the given Si is of N-type.");
//Note : Ans in the book is wrong. Mistake in value
    putting.
```

Scilab code Exa 5.6 Determine junction capacitance

```
//Exa 5.6
clc;
clear;
close;
//given data
CTzero=50;//in pF
VR=8;//in Volt
VK=0.7;//in Volt
n=1/3;//for Si
CT=CTzero/((1+VR/VK)^n);//in pF
disp(CT,"Junction capacitance in pF : ");
```

Chapter 6

Bipolar Junction Transistors

Scilab code Exa 6.1 Determine emitter current

```
//Exa 6.1
clc;
clear;
close;
//given data
IC=20;//in mA
Beta=50;//Unitless
IB=IC/Beta;//in mA
IE=IC+IB;//in mA
disp(IE,"Emitter current in mA : ");
```

Scilab code Exa 6.2 Determine emitter current amplification factor and gain factor

```
//Exa 6.2
clc;
clear;
close;
```

```
//given data
IC=0.98;//in mA
IB=20;//in uA
IB=IB*10^-3;//in mA
//part (i)
IE=IB+IC;//in mA
disp(IE,"Emitter current in mA :");
//part (ii)
alfa=IC/IE;//unitless
disp(alfa,"Current amplification factor : ");
//part (iii)
Beta=IC/IB;//unitless
disp(Beta,"Current gain factor : ");
```

Scilab code Exa 6.3 Determine emitter current and collector current

```
//Exa 6.3
clc;
clear;
close;
//given data
alfaDC=0.98;//unitless
ICBO=4;//in uA
ICBO=ICBO*10^-3;//in mA
IB=50;//in uA
IB=IB*10^-3;//in mA
//Formula : IC=alfaDC*(IB+IC)+ICBO
IC=alfaDC*IB/(1-alfaDC)+ICBO/(1-alfaDC);//in mA
IE=IC+IB;//in mA
disp(IE,"Emitter current in mA : ");
disp(IC,"Collector current in mA : ");
```

Scilab code Exa 6.4 Determine collector current

```
//Exa 6.4
clc;
clear;
close;
//given data
IB=10;//in uA
IB=IB*10^-3;//in mA
Beta=99;//Unitless
ICO=1;//in uA
ICO=ICO*10^-3;//in mA
//Formula : IC=alfa*(IB+IC)+ICO
IC=Beta*IB+(1+Beta)*ICO;//in mA
disp(IC,"Collector current in mA : ");
```

Scilab code Exa 6.5 Calculate dynamic input resistance

```
//Exa 6.5
clc;
clear;
close;
//given data
delVEB=200;//in Volts
delIE=5;//in mA
rin=delVEB/delIE;//in ohm
disp(rin,"Dynamic input resistance in ohm : ");
```

Scilab code Exa 6.6 Determine base and collector current

```
//Exa 6.6
clc;
clear;
close;
//given data
```

```
alfao=0.98;//unitless
ICO=10;//in uA
ICO=ICO*10^-3;//in mA
IE=2;//in mA
IC=alfao*IE+ICO;//in mA
IB=IE-IC;//in mA
disp(IC,"Collector current in mA : ");
disp(IB*1000,"Base current in uA : ");
```

Scilab code Exa 6.7 Determine current gain and base current

```
//Exa 6.7
clc;
clear;
close;
//given data
ICBO=12.5;//in uA
ICBO=ICBO*10^-3;//in mA
IE=2;//in mA
IC=1.97;//in mA
alfa=(IC-ICBO)/IE;//unitless
IB=IE-IC;//in mA
disp(alfa,"Current gain : ");
disp(IB,"Base current in mA : ");
```

Scilab code Exa 6.8 Determine base current

```
//Exa 6.8
clc;
clear;
close;
//given data
RL=4;//in Kohm
```

```
VL=3;//in volt
alfa=0.96;//unitless
IC=VL/RL;//in mA
IE=IC/alfa;//in mA
IB=IE-IC;//in mA
disp(IB,"Base current in mA : ");
```

Scilab code Exa 6.9 Determine base current

```
//Exa 6.9
clc;
clear;
close;
//given data
RL=1;//in Kohm
VL=1.2;//in volt
Beta=60;//unitless
IC=VL/RL;//in mA
IB=IC/Beta;//in mA
disp(IB*1000,"Base current in uA : ");
```

Scilab code Exa 6.10 Determine collector emitter voltage and base current

```
//Exa 6.10
clc;
clear;
close;
//given data
VCC=10;//in volt
RL=800;//in ohm
VL=0.8;//in volt
alfa=0.96;//unitless
```

```
//VR=IC*RL
VCE=VCC-VL;//in Volt
disp(VCE,"Collector-emitter Voltage in volts : ");
IC=VL*1000/RL;//in mA
Beta=alfa/(1-alfa);//unitless
IB=IC/Beta;//in mA
disp(IB*1000,"Base current in uA : ");
```

Scilab code Exa 6.11 Determine collector current

```
//Exa 6.11
clc;
clear;
close;
//given data
alfao=0.98;//unitless
ICO=10;//in uA
ICO=ICO*10^-3;//in mA
IB=0.22;//in mA
IC=(alfao*IB+ICO)/(1-alfao);//in mA
disp(IC,"Collector current in mA : ");
```

Scilab code Exa 6.12 Calculate dynamic input resistance

```
//Exa 6.12
clc;
clear;
close;
//given data
delVEB=250;//in mVolts
delIE=1;//in mA
rin=delVEB/delIE;//in ohm
disp(rin,"Dynamic input resistance in ohm : ");
```

Scilab code Exa 6.13 Calculate dynamic output resistance

```
//Exa 6.13
clc;
clear;
close;
//given data
delVCE=10-5;//in Volts
delIC=5.8-5;//in mA
rin=delVCE/delIC;//in Kohm
disp(rin,"Dynamic output resistance in Kohm : ");
```

Scilab code Exa 6.14 Determine operating point

```
//Exa 6.14
clc;
clear;
close;
//given data
VCC=10;//in volt
RC=8;//in Kohm
Beta=40;//unitless
IB=15;//in uA
IB=IB*10^-3;//in mA
// For VCE = 0 Volts
IC=VCC/RC;//in mA
disp(IC,"VCE=0V and IC in mA = ");
disp("This gives a point on loasd line.");
//For IC=0 VCE=VCC=10V :
disp("For IC=0, VCE=VCC=10V :")
disp("This gives another point on load line.");
```

```
IC=Beta*IB;//in mA
VCE=VCC-IC*RC;//in Volts
disp("Operating point Q is ("+string(VCE)+"V,"+
    string(IC)+"mA)");
```

Scilab code Exa 6.15 Find VCE at cut off point

```
//Exa 6.15
clc;
clear;
close;
//given data :
VCC=20;//in Volt
RC=3.3*10^3;//in ohm
disp("Applying Kirchoffs Voltage Law : ");
disp("VCC=IC*RC+VCE");
disp("For cut-off point, IC=0");
disp("Therefore, VCC=VCE");
VCE=VCC;//in volt
disp(VCE,"VCE at cut-off point : ");
disp("For Saturation point, VCE = 0");
VCE=0;//in volts
IC=VCC/RC;//in A
disp(IC,"IC at saturation point in mA ; ");
disp("Therefore Load line coordinates are given as :
     ");
disp("("+string(20)+"V,"+string(0)+"mA)");
disp("("+string(VCE)+"V,"+string(IC*1000)+"mA)");
```

Scilab code Exa 6.16 Determine VC and VB

```
//Exa 6.16
clc;
```

```
clear;
close;
//given data :
Beta=45;//Unitless
VBE=0.7;//in Volt
VCC=0;//in Volt
RB=10^5;//in ohm
RC=1.2*10^3;//in ohm
VEE=-9;//in Volt
disp("Applying Kirchoffs Voltage Law in input loop
    we have : ");
disp("IB*RB+VBE+VEE=0");
IB=-(VBE+VEE)/RB;//in mA
IC=Beta*IB;//in mA
VC=VCC-IC*RC;//in Volts
VB=VBE+VEE;//in Volts
disp(VC,"VC in volts : ");
disp(VB,"VB in volts : ");
```

Scilab code Exa 6.17 Find IB and IC

```
//Exa 6.17
clc;
clear;
close;
//given data :
Beta=100;//Unitless
hfe=Beta;//Unitless
VBB=5;//in Volt
VBE=0.8;//in Volt
RB=50*10^3;//in ohm
RE=2*10^3;//in ohm
VCE=0.2;//in Volt
disp("Applying Kirchoffs Voltage Law in input loop
    we have : ");
```

```
disp("VBB=IB*RB+VBE+IE*RE=IB*RB+VBE+(1+Beta)*IB*RE");
disp("IB=(VBB-VBE)/(RB+(1+Beta)*RE)");
IB=(VBB-VBE)/(RB+(1+Beta)*RE);//in A
disp(IB*1000,"IB in mA : ");
disp("Applying Kirchoffs Voltage Law in output loop we have : ");
disp("10-IC(3*10^3)-VCE-IE(2*10^3)=0");
IC=(10-0.2)/(5*10^3);//in A
disp(IC*1000,"IC in mA : ");
disp(Beta*IB,"Beta*Ib in mA = ");
disp(IC,"IC = ");
disp("IC > Beta*IB. Hence the transistor is in saturation with the values of IB = 0.0166 mA and IC = 1.96 mA.")
```

Chapter 7

Field Effect Transistors

Scilab code Exa 7.1 Determine resistance between gate and source

```
//Exa 7.1
clc;
clear;
close;
//given data :
VGS=10;//in Volt
IG=0.001;//in uA
IG=IG*10^-6;//in A
RGS=VGS/IG;//in ohm
disp(RGS/10^6,"Resistance between gate and source in
    Mohm ; ");
```

Scilab code Exa 7.2 Calculate AC drain resistance

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

```
//given data :
delVDS=1.5;//in Volt
delID=120;//in uA
delID=120*10^-6;//in A
rd=delVDS/delID;//in Ohm
disp(rd*10^-3,"AC drain resistance of JFET in Kohm :
    ");
```

Scilab code Exa 7.3 Determine Transconductance

```
//Exa 7.3
clc;
clear;
close;
//given data :
VP=-4.5;//in Volt
IDSS=10;//in mA
IDS=2.5;//in mA
disp("From shockleys equation, drain source current,
    IDS=IDSS*(1-VGS/VP)^2 ");
VGS=VP*(1-sqrt(IDS/IDSS));//in Volt
gm=(-2*IDSS/VP)*(1-VGS/VP);//in mA/Volt
disp(gm,"Transconductance in mA/Volt : ");
```

Scilab code Exa 7.4 Calculate VGS

```
//Exa 7.4
clc;
clear;
close;
//given data :
gm=10;//in mS
IDSS=10;//in uA
```

```
IDSS=IDSS-10^-6;//in Ampere
disp("VGS(OFF) : VGS=VP");
disp("gm=gmo=-2*IDSS/VP=-2*IDSS/VGS(OFF)");
VGS_OFF=-2*IDSS/gm
disp(round(VGS_OFF),"VGS(OFF) in mV :");
```

Scilab code Exa 7.5 Determine minimum value of VDS

```
//Exa 7.5
clc;
clear;
close;
//given data :
VP=-4;//in Volt
IDSS=10;//in mA
IDSS=IDSS*10^-3;//in Ampere
VGS=-2;//in Volt
ID=IDSS*(1-VGS/VP)^2;//in mA
disp(ID*1000,"Drain current in mA : ");
disp("The minimum value of VDS for pinch-OFF region
    is equal to VP. Thus the minimum value of VDS : "
    );
disp(VP,"VDS(min) in volt : ");
```

Scilab code Exa 7.6 Findd values of ID gmo and gm

```
//Exa 7.6
clc;
clear;
close;
//given data :
VP=-3;//in Volt
IDSS=8.7;//in mA
```

```
IDSS=IDSS*10^-3;//in mA
VGS=-1;//in Volt
ID=IDSS*(1-VGS/VP)^2;//in Ampere
disp(ID*1000,"ID in mA : ")
gmo=-2*IDSS/VP;//in mS
disp(gmo*1000,"gmo in mS : ");
gm=gmo*(1-VGS/VP);//in mS
disp(gm*1000,"gm in mS : ");
```

Scilab code Exa 7.7 Findd values of ID and gm

```
//Exa 7.7
clc;
clear;
close;
//given data :
VP=-3;//in Volt
IDSS=8.4;//in mA
VGS=-1.5;//in Volt
ID=IDSS*(1-VGS/VP)^2;//in mA
disp(ID,"Drain current in mA : ");
gmo=-2*IDSS/VP;//in mS
gm=gmo*(1-VGS/VP);//in mS
disp(gm,"gm in mS : ");
```

Scilab code Exa 7.8 Find value of VGS and gm

```
//Exa 7.8
clc;
clear;
close;
//given data :
VP=-4.5;//in Volt
```

```
IDSS=9;//in mA
IDSS=IDSS*10^-3;//in Ampere
IDS=3;//in mA
IDS=IDS*10^-3;//in Ampere
VGS=VP*(1-sqrt(IDS/IDSS));//in Volt
disp(VGS,"IDS = 3 mA when VGS(in Volt) is : ");
gm=(-2*IDSS/VP)*(1-VGS/VP);//in mS
disp(gm*1000,"IDS = 3 mA when gm(in mS) is : ");
```

Scilab code Exa 7.9 Sketch the transfer Characteristics

```
//Exa 7.9
clc;
clear;
close;
//given data :
VP=-4;//in Volt
IDSS=10;//in mA
VGS=[0 1 -1 -2 -4];
ID=zeros(1,5);
for i=1:5
    ID(i)=IDSS*(1-VGS(i)/VP)^2;//in mA
end
plot2d(VGS,ID);
```

Scilab code Exa 7.10 Determine Drain current

```
//Exa 7.10
clc;
clear;
close;
//given data :
ID_on=5;//in mA
```

```
VGS=6;//in Volt
VGS_on=8;//in Volt
VGST=4;//in Volt
K=ID_on/(VGS_on-VGST)^2;//in mA/V^2
ID=K*(VGS-VGST)^2;//in mA
disp(ID,"When VGS=6V the drain current in mA : ");
```

Chapter 8

Photonic Devices

Scilab code Exa 8.1 Determine steady state photo current density

```
//Exa 8.1
clc;
clear;
close;
//given data :
NA=10^22;//in atoms/m^3
ND=10^22;//in atoms/m^3
De=25*10^-4;//in m^2/s
Dh=10^-3;//in m^2/s
TAUeo=500;//in ns
TAUho=100;//in ns
ni=1.5*10^16;//in atoms/m^3
VR=-10;//in Volt
epsilon=11.6*8.854*10^-12;//in F/m
e=1.6*10^-19;//in Coulamb
VT=26;//in mV
GL=10^27;//in m^-3 s^-1

Le=sqrt(De*TAUeo*10^-9);//in um
Le=Le*10^6;//in um
Lh=sqrt(Dh*TAUho*10^-9);//in um
```

```
Lh=Lh*10^6;//in um
Vbi=VT*10^-3*log(NA*ND/ni^2);//in Volt
Vo=Vbi;//in Volt
VB=Vo-VR;//in Volt
W=sqrt((2*epsilon*VB/e)*(1/NA+1/ND));//in um
W=W*10^6;//in um
JL=e*(W+Le+Lh)*10^-6*GL;//in A/cm^2
disp(JL/10^4,"Steady state photocurrent density in A
    /cm^2 : ");
```

Scilab code Exa 8.2 Determine photo current density

```
//Exa 8.2
clc;
clear;
close;
//given data :
W=25;//in um
PhotonFlux=10^21;//in m^2s^-1
alfa=10^5;//in m^-1
e=1.6*10^-19;//in Coulambs
GL1=alfa*PhotonFlux;//in m^-3s^-1
GL2=alfa*PhotonFlux*exp(-alfa*W*10^-6);//in m^-3s^-1
JL=e*PhotonFlux*(1-exp(-alfa*W*10^-6));//in mA/cm^2
disp(JL/10,"Steady state photocurrent density in mA/
    cm^2 : ");
```

Scilab code Exa 8.3 Determine open circuit voltage

```
//Exa 8.3
clc;
clear;
close;
```

```
//given data :
NA=7.5*10^24;//in atoms/m^3
ND=1.5*10^22;//in atoms/m^3
De=25*10^-4;//in m^2/s
Dh=10^-3;//in m^2/s
TAUeo=500;//in ns
TAUho=100;//in ns
ni=1.5*10^16;//in atoms/m^3
VR=-10;//in Volt
epsilon=11.6*8.854*10^-12;//in F/m
e=1.6*10^-19;//in Coulamb
VT=26;//in mV
GL=10^27;//in m^-3 s^-1

Le=sqrt(De*TAUeo*10^-9);//in um
Le=Le*10^6;//in um
Lh=sqrt(Dh*TAUho*10^-9);//in um
Lh=Lh*10^6;//in um
JS=e*(ni^2)*(De/(Le*10^-6*NA)+De/(Lh*10^-6*ND));//in A/cm^2
JL=12.5;//in mA/cm^2
VOC=VT*log(1+JL/JS);//in Volt
disp(VOC,"Open circuit voltage in Volt : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 8.4 Determine approximate no of solar cell required

```
//Exa 8.4
clc;
clear;
close;
//given data :

disp("Each cell supplies 50 mA at 0.45V. Allowing for the voltage drop across the rectifier and
```

```
    series resistor, a maximum output voltage of
    approximately 28V is required. Thus, ");
disp("n = Vout/Vcell");
Vout=28;//in Volts
Vcell=0.45;//in Volt
n=Vout/Vcell;//Unitless
disp(n,"No. of series connected- cells = ");
disp("the charge taken from the batteries over a
    period of 24 hour is 24*0.5 =  12 Ah. thus, the
    charge delivered by the solar cells must be 12
    ampere Hours");
disp("Since the solar cells are illuminated only 12
    hours a day, the necessary charging current from
    the solar cell is 12Ah/12h i.e. 1 A");
Iout=1;//in A
Icell=50;//in mA
m=Iout/(Icell*10^-3);//unitless
disp(m,"Hence total no. of group of cells in
    parallel, m ");
disp(round(m*n),"The total no. of cells required : "
    );
//Note : Answer in the book is wrong.
```