Scilab Textbook Companion for Electrical And Electronics Engineering Materials by J. B. Gupta[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

Crystal Stucture Of Materials

Scilab code Exa 1.3 Density Of Copper Crystal

```
//Exa3
clc;
clear;
close;
//given data
//atomic radius
r=1.278; //in Angstrum
//atomic weight
aw=63.5;
//Avogadro's number
an=6.023*10^23;
//copper has FCC structure for which
a=(4*r)/sqrt(2);// in Angstrum
a=a*10^-10;//in m
//Mass of one atom
m=aw/an;//in gm
m=m*10^-3;//in kg
//volume of one unit cell of copper crystal,
V=a^3;//in meter cube
//Number of atoms present in one unit cell of Cu(FCC Structure),
```

```
n=4;
//Density of crystal
rho=(m*n)/V;//in kg/m^3
disp("Density of crystal is : "+string(rho)+"kg/m^3");
```

Scilab code Exa 1.4 Interplanar Distance in a crystal

```
//Exa4
clc;
clear;
close;
//given data :
//wavelength
lamda=1.539; //in Angstrum
//angle
theta=22.5; // in degree
n=1;//(first order)

// Formula n*lamda=2*d*sin(theta) , so
// interplaner distance ,
d=lamda/(2*sin(theta*%pi/180));
disp("Interplaner distance is : "+string(d)+" Angstrum")
```

Scilab code Exa 1.5 Wavelength of X rays

```
//Exa5
clc;
clear;
close;
//given data :
n=2;
```

```
d=0.4;// in nenometer
d=d*10^-9;// in meter
theta=16.8/2;// in degree
//using Bragg's equation we have n*lamda=2*d*sin(theta), so
lamda=(2*d*sin(8.4*%pi/180))/n;
disp("Wavelength of X-rays used is : "+string(lamda*10^10)+" Angstrum");
```

Scilab code Exa 1.6 `Wavelength of X rays`

```
//Exa6
clc;
clear;
close;
//given data :
a=3.15; //in Angstrum
a=a*10^-10;//in meter
//angle
theta=20.2;//in degree
n=1;//(first order)
//for BCC crystal
d110=a/sqrt(2);//in meter
//Formula n*lamda=2*d*sin(theta)
lamda=(2*d110*sin(theta*%pi/180))/n;//in meter
disp("Wavelength is : "+string(lamda*10^10)+" Angstrum")
```

Scilab code Exa 1.7 `Angle of incidence`

```
//Exa7
clc;
clear;
```

```
close;
//given data :
lambda=0.842; //in Angstrum
lambda=lambda*10^-10; // in meter
//theta=8degree 35minutes
theta=8+35/60;//in degree
n=1;//(first order)
//Formula n*lamda=2*d*sin(theta)
d=n*lambda/(2*sind(theta))
//For third Order reflection :
//Formula n*lamda=2*d*sin(theta)
n=3;//order
theta=asind(n*lambda/(2*d));
disp(round(theta),"Angle of incidence for third
    order reflection in degree : ");
```

Chapter 2

Conductivity of metals

Scilab code Exa 2.1 Drift Velocity of Electrons

```
//Exa2.1
clc;
clear;
close;
//given data :
J=2.4; //in A/mm^2
J=2.4*10^6; //in A/m^2
n=5*10^28; //unitless
e=1.6*10^-19; // in coulomb
//Formula : J=e*n*v
v=J/(e*n);//in m/s
disp("Drift velocity is : "+string(v)+" m/s or "+
   string(v*10^3)+" mm/s")
```

Scilab code Exa 2.2 Magnitude of current

```
//Exa2
clc;
```

```
clear;
close;
//given data :
//Electron density
n=1*10^24;//unit less
//Electron charge
e=1.6*10^-19; // in coulomb
//Drift velocity
v=1.5*10^-2; // in meter per second
//cross-sectional area
A=1; // in centimeter square
A=1*10^-4; // in meter square
I=e*n*v*A;// in ampere
disp("Magnitude of current is :"+string(I)+" A")
```

Scilab code Exa 2.3 Relaxation time and resistivity

```
//Exa2.3
clc;
clear;
close;
//given data :
miu_e=7.04*10^-3; //in m^2/V-s
n=5.8*10^28 ; // in /m^3
e=1.6*10^-19; // in coulomb
m=9.1*10^-31;//in kg
//(i) Relaxation time,
tau=miu_e/e*m;
disp("Relaxation time is : "+string(tau)+" second");
sigma=(n*e*miu_e);
//(ii) Resistivity of conductor,
rho=1/sigma;
disp("Resistivity of conductor is : "+string(rho)+"
    ohm-meter");
```

Scilab code Exa 2.4 Valance electron and mobility of electron

```
//Exa4
clc;
clear;
close;
//given data :
rho=1.73*10^-8;//in ohm-meter
toh=2.42*10^-14 ; //in second
e=1.6*10^-19; //in C
m=9.1*10^-31;//in kg
sigma=1/rho;
//(i) Number of free electrons per m^3
n=(m*sigma)/(e^2*toh);
disp("Number of free electrons per cube meter is : "
    +string(n));
//(ii) Mobility of electrons ,
miu_e=(e*toh)/m;
disp("Mobility of electrons is : "+string(miu_e)+" m
    ^2/V-s");
//Note: Answer in the book is wrong
```

Scilab code Exa 2.5 Mobility and relaxation time

```
//Exa5
clc;
clear;
close;
//given data :
rho=1.54*10^-8; //in ohm-meter
//since sigma=1/roh
sigma=1/rho;
```

```
n=5.8*10^28 ; //unit less
e=1.6*10^-19; //in C (electron charge)
m=9.1*10^-31;//in kg (mass of electron)
//(i) Relaxation time
toh=(sigma*m)/(n*e^2);
disp("(i) Relaxation time of electrons is : "+string
    (toh)+" seconds");
//(ii) Mobility of electrons ,
miu_e=(e*toh)/m;
disp("(ii) Mobility of electrons is : "+string(miu_e
    )+" m^2/V-s");
```

Scilab code Exa 2.6 Relaxation time

```
//Exa2.6
clc;
clear;
close;
//given data :
rho=1.7*10^-8; //in ohm-meter
//since sigma=1/roh
sigma=1/rho;
n=8.5*10^28 ; //unit less
e=1.6*10^-19; //in C (electron charge)
m=9.1*10^-31;//in kg
// Relaxation time
toh=(sigma*m)/(n*e^2);
disp(" Relaxation time of electrons is : "+string(
    toh)+" seconds");
```

Scilab code Exa 2.7 Relaxation time of conducting electrons

```
//Exa2.7
```

```
clc;
clear;
close;
format('v',11);
//given data :
E=100;//in V/m
rho=1.5*10^-8; //in ohm-meter
//since sigma=1/roh
sigma=1/rho;
n=6*10^28 ; //unit less
e=1.601*10^-19; //in C
m=9.107*10^-31;//in kg
// Relaxation time
toh=(sigma*m)/(n*e^2);
disp("(i) Relaxation time of electrons is : "+string
   (toh)+" seconds");
//Drift velocity
v=(e*E*toh)/m;
disp("(ii) Drift velocity is : "+string(v)+" m/s");
```

Scilab code Exa 2.8 Charge density current density and drift velocity

```
//Exa2.8
clc;
clear;
close;
//given data :
//Diameter of copper wire
d=2;//in milimeter
d=.002;//in meter
//conductivity of copper
nita=5.8*10^7;//in second per meter
//Electron mobility
miu_e=.0032;//in meter square per volt-second
//Applied electric field
```

```
E=20;//in mV/m
E=.02; //in V/m
e=1.6*10^-19;
//(i) From eq. (2.13)
//charge density
n=nita/(e*miu_e);//in per meter cube
disp("(i) Charge density is : "+string(n)+" /meter
    cube");
//(ii) from eq. (2.9)
//current density
J=nita*E;// in A/m^2
disp("(ii) Current density is : "+string(J)+" A/m^2"
    );
//(iii) Current flowing in the wire I=J* Area of x-
    section of wire
// Area of x-section of wire= (%pi*d^2)/4
I=(J*%pi*d^2)/4;
disp("(iii) Current flowing in the wire is : "+
    string(I)+" A");
//(iv) form eq.2.14
//Electron drift velocity
v=miu_e*E;
disp("(iv) Electron drift velocity is :"+string(v)+"
     m/s");
```

Scilab code Exa 2.9 `Drift velocity`

```
//Exa2.9
clc;
clear;
close;
//given data
rho=0.5; // in ohm-meter
J=100; //in A/m^2
miu_e=0.4; //in m^2/V-s
```

```
E=J*rho; // since E=J/sigma
// Formula v=miu_e*E
v=miu_e*E;
disp(" Electron drift velocity is : "+string(v)+" m/
   s");
disp("Time taken by the electron to travel 10*10^-6
   m in crystal")
// let Time taken by the electron to travel 10*10^-6
    m in crystal = t
t=(10*10^-6)/v;
disp(string(t)+" second");
```

Scilab code Exa 2.10 Resistivity of silicon

```
//Exa10
clc;
clear;
close;
//given data
miu_e=0.17;//in m^2/V-s
miu_h=0.035;//in m^2/V-s
nita_i=1.1*10^16; //in /m^3
e=1.6*10^-19;// in C (electron charge)
// Intrinsic conductivity ,
sigma_i=(nita_i*e)*(miu_e+miu_h);
IntrinsicResistivity=1/sigma_i;
disp("Intrinsic resistivity is : "+string(
   IntrinsicResistivity)+" ohm-meter");
```

Scilab code Exa 2.11 Carrier density

```
//Exa11
clc;
```

```
clear;
close;
//given data
rho_i=2*10^-3; //in ohm-m  (there is miss printed in
    this line in the book)
sigma_i=1/rho_i;
miu_e=0.3;// in m^2/V-s
miu_h=0.1;//  in m^2/V-s
e=1.6*10^-19; // in C
// Formula sigma_i=nita_i*e*(miu_e+miu_h)
nita_i=sigma_i/(e*(miu_e+miu_h));
disp("Carrier density is : "+string(nita_i)+" /m^3")
   ;
```

Scilab code Exa 2.13 Temperature of coil

```
//Exa2.13
clc;
clear;
close;
//given data
R_15=250;// in ohm
R_t2=300 ;// in ohm
alpha=0.0039;// in degree C
t1=15;
//Formula R_t2 = R_15 * [1 + alpha1*(t2 - t1)]
t2=((R_t2/R_15)-1)/alpha+t1;
disp("Temperature when its resistance is 300 ohms is
    : "+string(t2)+" degree C");
```

Scilab code Exa 2.15 Resistance of the coil

```
//Exa2.15
```

```
clc;
clear;
close;
//given data
alpha0=0.0038;// in ohm/ohm/degree C
t1=20; //in degree C
alpha20=1/(1/alpha0+t1);
R1=400;//in ohm
//Formula R2=R1*[1+alpha20*(t2-t1)]
R2=R1*[1+alpha20*(80-20)];
disp("Resistance of wire at 80 degree C si : "+
   string(R2)+" ohm")
```

Scilab code Exa 2.16 Temperature coefficient of resistance

```
//Exa2.16
clc;
clear;
close;
disp("Let the temperature coefficient of resistance
   of material at 0 degree C be alpha0");
disp("Resistance at 25 degree C, R1 = R0 * (1+25*
   alpha0)                    (i)");
disp("Resistance at 70 degree C, R2 = R0 * (1+70*
   alpha0)                    (ii)");
disp("Dividing Eq.(ii) by Eq.(i), we get");
disp("R2/R1= (1+70*alpha0)/(1+25*alpha0)");
disp("or  57.2/50 = (1+70*alpha0)/(1+25*alpha0)");
disp("or alpha0 = 0.00348 ohm/ohm/degree C");
```

Scilab code Exa 2.17 Temperature coefficient of resistance

```
//Exa2.17
```

```
clc;
clear;
close;
disp("Let the temperature coefficient of resistance of material coil at 0 degree C be alpha0,then");
disp("Resistance at 25 degree C, R1 = R0 * (1+25*alpha0)                (i)");
disp("Resistance at 75 degree C, R2 = R0 * (1+75*alpha0)                (ii)");
disp("Dividing Eq.(ii) by Eq.(i), we get");
disp("R2/R1= (1+75*alpha0)/(1+25*alpha0)");
disp("or  49/45 = (1+75*alpha0)/(1+25*alpha0)");
disp("or alpha0 = 0.00736 ohm/ohm/degree C");
```

Scilab code Exa 2.18 Resistance and temperature coefficient

```
//Exa2.18
clc;
clear;
close;
disp("Let the temperature coefficient of resistance of platinum at 0 degree C be alpha0 and resistance of platinum coil at 0 degree C be R0, then");
disp("Resistance at 40 degree C, R1 = R0 * (1+40*alpha0)                (i)");
disp("Resistance at 100 degree C, R2 = R0 * (1+100*alpha0)                (ii)");
disp("Dividing Eq.(ii) by Eq.(i), we have");
disp("R2/R1= (1+100*alpha0)/(1+40*alpha0)");
disp("or  3.767/3.146 = (1+100*alpha0)/(1+40*alpha0)");
disp("or alpha0 = 0.00379 ohm/ohm/degree C");
alpha0=0.00379;// in ohm/ohm/degree C
disp("Temperature coefficient of resistance at 40
```

```
degree C,")
alpha40=1/(1/alpha0+40);
disp(alpha40);
disp("Substituting R1=3.146 and alpha0=0.00379 in Eq.(i) we have")
R1=3.146;//in ohm
//Formula R1 = R0 * (1+40*alpha0)
R0=R1/(1+40*alpha0);
disp("Resistance of platinum coil at 0 degree C is : "+string(R0)+" ohm ");
```

Scilab code Exa 2.19 Mean temperature rise

```
//Exa2.19
clc;
clear;
close;
disp("Let R0 be the resistance of the coil at 0 degree C and alpha0 be its temperature coefficient of resistance at 0 degree C");
disp("Resistance at 20 degree C, 18 = R0 * (1+20*alpha0)                    (i)");
disp("Resistance at 50 degree C, 20 = R0 * (1+50*alpha0)                    (ii)");
disp("Dividing Eq.(ii) by Eq.(i), we have");
disp("20/18= (1+50*alpha0)/(1+20*alpha0)");
disp("or alpha0 = 1/250=0.004 ohm/ohm/degree C");
disp("If t degree C is the temperature of coil when its resistance is 21 ohm, then");
disp("21=R0*(1+0.004*t)");
disp("Dividing Eq.(iii) by Eq.(ii), we have");
disp("21/20=(1+0.004*t)/(1+50*0.004)");
disp("or t=65 degree C");
disp("Temperature rise = t-surrounding temperature = 65 - 15 = 50 degree C");
```

Scilab code Exa 2.20 Specific resistance and resistance temperature coefficient

```
//Exa2.20
clc;
clear;
close;
//given data
alpha20=1/254.5;// in ohm/ohm/degree C
t2=60;//degree C
t1=20;//degree C
rho0=1.6*10^-6;
alpha60=1/(1/alpha20+(t2-t1));
disp("Temperature coefficient of resistance at 60
    degree C is : "+string(alpha60)+" ohm/ohm/degree
    C");
//from alpha20=1/(1/alpha0+20)
alpha0=1/(1/alpha20-20);
//Formula rho60=rho0*(1+alpha0*t)
rho60=rho0*(1+alpha0*t2);
disp("Specific resistance at 60 degree C is : "+
    string(rho60)+" ohm-cm")
```

Scilab code Exa 2.21 Resistivity of the wire material

```
//Exa2.21
clc;
clear;
close;
//given data
R=95.5;//in ohm
l=1;//in meter
```

```
d=0.08;//in mm
d=d*10^-3;//in meter
a=(%pi*d^2)/4;
//Formula R=rho*l/a
rho=R*a/l;
disp("Resistance of the wire material is : "+string(rho)+" ohm-meter")
```

Scilab code Exa 2.22 `Resistance of the wire`

```
//Exa2.22
clc;
clear;
close;
//given data
R=4;//in ohm
d=0.0274;//in cm
d=0.000274;//in meter
rho=10.3;//in miu ohm-cm
rho=10.3*10^-8;//in ohm-m
a=(%pi*d^2)/4;

//Formula R=rho*l/a
l=R*a/rho;
disp("Lenght of wire is : "+string(l)+" meters")
```

Scilab code Exa 2.23 `Current flowing`

```
//Exa2.23
clc;
clear;
close;
//given data
```

```
V=220;// in V
W=100;//in watt
R100=V^2/W;//in ohm
alpha20=0.005;
t1=20;
t2=2000;
// since R100=R20*[1+alpha20*(t2-t1)]
R20=R100/(1+alpha20 * (t2-t1));
I20=V/R20;
disp("Current flowing at the instant of switching on a 100 W metal filament lamp is : "+string(I20)+" A")
```

Scilab code Exa 2.24 Resistance and temperature coefficient of combination

```
//Exa2.24
clc;
clear;
close;
//given data
t2=50;// in degree C
t1=20; // in degree C
R1=600;// in ohm
R2=300;// in ohm

// Let resistance of 600 ohm resistance at 50 degree C = R_600
R_600=R1*(1+(t2-t1)*.001);// in ohm
// Let resistance of 300 ohm resistance at 50 degree C = R_300
R_300=R2*(1+(t2-t1)*.004);// in ohm
R_50=R_600+R_300;// in ohm
disp("Resistance of combination at 50degree C is : "+string(R_50)+ " ohm")
R_20=R1+R2;// in ohm
```

```
alpha_20=(R_50/R_20-1)/(t2-t1);
alpha_50=1/(1/(alpha_20)+(t2-t1));
disp("Effective temperature coefficient of
   combination at 50 degree C is : "+string(alpha_50
   )+"  or 1/530 per degree C")
```

Scilab code Exa 2.25 Impurity percent

```
//Exa2.25
clc;
clear;
close;
//given data
toh=1.73//in micro-ohm-cm
tohDesh=1.74;//in micro-ohm-cm
sigma=1/toh;// conductivities of pure metal
sigmaDesh=1/tohDesh;//conductivities metal with
   impurity
PercentImpurity=((sigma-sigmaDesh)/sigma)*100;
disp(" Percent impurity in the rod is : "+string(
   PercentImpurity)+" %")
```

Scilab code Exa 2.26 Electronic contribution of thermal conductivity of aluminium

```
//Exa2.26
clc;
clear;
close;
//given data
ElectricalResistivity=2.86*10^-6;//in ohm-cm
sigma=1/ElectricalResistivity;
T=273+20;// in Kelvin (Temperature)
//Formula K/(sigma*T)=2.44*10^-8
```

```
disp("Thermal conductivity of Al ")
K=(2.44*10^-8*T*sigma);
disp(K);
```

Scilab code Exa 2.27 EMP developed per degree centigrade

```
//Exa2.27
clc;
clear;
close;
//given data
E_AC=16*10^-6;//in V per degree C
E_BC=-34*10^-6;//in V per degree C
//By law of successive contact (or intermediate metals)
E_AB=E_AC-E_BC;//in V/degree C
E_AB=E_AB*10^6;// in miu V/degree C
disp("EMF of iron with respect to constantan is : "+string(E_AB)+" micro V/degree C")
```

Scilab code Exa 2.28 EMF developed in couple

```
//Exa2.28
clc;
clear;
close;
//given data
E_AC=7.4;//in miu V per degree C
E_BC=-34.4;//in miu V per degree C
//By law of successive contact (or intermediate metals)
E_AB=E_AC-E_BC;//in miu V/degree C
E_AB=E_AB*10^-6;// in  V/degree C
```

```
// Let Thermo-emf for a temperature difference of 250 degree C = EMF_250
EMF_250=E_AB*250;// in V
EMF_250=EMF_250*10^3;//in mV
disp("Termo-emf for a temperature difference of 250 degree C is "+string(EMF_250)+" mV");
```

Scilab code Exa 2.29 Thermo electric emf generated

```
//Exa2.29
clc;
clear;
close;
//given data
//Take iron as metal A and copper as metal B with respect to lead
//For metal A:
p_A=16.2;
q_A=-0.02;
//For metal B:
p_B=2.78;
q_B=+0.009;
p_AB=p_A-p_B;
q_AB=q_A-q_B;
T2=210;//in degree C
T1=10;// in degree C
E=p_AB*(T2-T1)+q_AB/2*(T2^2-T1^2);
disp("Thermo-electric emf is : "+string(E)+" micro V");
Tn=-p_AB/q_AB;
disp("Neutral temperature is : "+string(Tn)+" degree C");
```

Scilab code Exa 2.30 Thermo emf neutral temperature temperature of inversion and m

```
//Exa2.30
clc;
clear;
close;
//given data
p_A=17.34;
q_A=-0.0487;
p_B=1.36;
q_B=+0.0095;
p_AB=p_A-p_B;
q_AB=q_A-q_B;
T2=210;//in degree C
T1=10;// in degree C
E=p_AB*(T2-T1)+q_AB/2*(T2^2-T1^2);//in miu V
E=E*10^-3;//in m V
disp("Thermo−electric emf is : "+string(ceil(E))+" m V");
Tn=-p_AB/q_AB;
disp("Neutral temperature is : "+string(ceil(Tn))+" degree C");
Tc=10;// in degree C
Ti=Tn+(Tn-Tc);
disp("Temperature of inversion is : "+string(ceil(Ti))+" degree C");
E_max=15.98*(275-10)-1/2*0.0582*[275^2-10^2];//in miu V
E_max=E_max*10^-3;// in mV
disp("Maximum possible thermo−electric emf at neutral temperature that is at 275 degree C is : "+string(E_max)+" mV");
```

Scilab code Exa 2.31 Potential difference

```
//Exa2.31
clc;
clear;
close;
//given data
rho=146*10^-6// in ohm-cm
a=1;//in cm^2
l=1;//in cm
// let current = i
i=0.06;//in amp
R=rho*l/a;//in ohm
// Let potential difference per degree centigrade = P
P=i*R;// By Ohm's law
disp("Potential difference per degree centigrade is : "+string(P)+" volt");
```

Scilab code Exa 2.32 `EMF for a copper iron thermo couple`

```
//Exa2.32
clc;
clear;
close;
//given data
T_lower=10;// in degree C
T_upper=150;// in degree C

// Thermo-electric power for iron at any temperature T degree C w.r.t. lead is given by (17.34-0.0487 T)*10^-6 and that for copper by (1.36-.0095 T)*10^-6

// Thermo-electric power, P=dE/dT
// or dE=P*dT
// Thermo-emf for copper between temperature 10
```

```
degree C and 150 degree C,
E_c= integrate('(1.36-0.0095*T)*10^-6','T',T_lower,T_upper);

// Thermo-emf for iron between temperature 10 degree C and 150 degree C,
E_i= integrate('(17.34-0.0487*T)*10^-6','T',T_lower,T_upper);

// Thermo-emp for copper-iron thermo-couple
E=E_i-E_c;

disp("Thermo-emf for iron between temperature 10 degree C and 150 degree C is : "+string(E*10^6)+" micro V");
```

Scilab code Exa 2.34 Critical magnetic field

```
//Exa2.34
clc;
clear;
close;
//given data
Hc_0=8*10^5;//in A/m
Tc=7.26;//in K
T=4;//in K
Hc_T=Hc_0*[1-(T/Tc)^2]';
disp("The critical value of magnetic field at T=4 K is : "+string(Hc_T)+" A/m");
```

Scilab code Exa 2.35 Critical current

```
//Exa2.35
```

```
clc;
clear;
close;
//given data
Hc=7900;//in A/m
d=1;//in mm
r=d/2;//in mm
r=r*10^-3;//in m
Ic=2*%pi*r*Hc;
disp("Critical current is : "+string(Ic)+" A");
```

Scilab code Exa 2.36 Critical current density

```
//Exa2.36
clc;
clear;
close;
//given data
Hc_0=8*10^4;//in A/m
Tc=7.2;//in K
T=4.5;//in K
d=1;//in mm
r=d/2;//in mm
r=r*10^-3;//in m
Hc=Hc_0*[1-(T/Tc)^2]';
disp("The critical field at T=4.5 K is : "+string(Hc
   )+" A/m");
Ic=2*%pi*r*Hc;
disp("Critical current is : "+string(Ic)+" A");
```

Scilab code Exa 2.37 Diameter of copper wire

```
//Exa2.37
```

```
clc;
clear;
close;
format('v',5)
// Formula R=rho*l/a
//putting value for copper wire
R=2;// in ohm
l=100;//in meter
rho=1.7*10^-8;// (for copper)
a=rho*l/R;//in meter
a=a*10^6;// in mm
// Formula a=%pi/4*d^2
d_copper=sqrt(a*4/%pi); //  (d_copper is diameter for copper)

// Formula R=rho*l/a
//putting value for Aluminium wire
R=2;// in ohm
l=100;//in meter
rho=2.8*10^-8;// (for aluminium)
a=rho*l/R;//in meter
a=a*10^6;// in mm
// Formula a=%pi/4*d^2
d_aluminium=sqrt(a*4/%pi); //  (d_aluminium is diameter for aluminium)
DiaRatio=d_aluminium/d_copper; //  (DiaRatio is ratio of diameter of aluminium and copper)
disp("The diameter of the aluminium wire is "+string(DiaRatio)+" times that of copper wire");
```

Scilab code Exa 2.38 Resistance of liquid resistor

```
//Exa2.38
clc;
clear;
```

```
close;
format('v',7)
//given data
l=60;// in cm
l=l*10^-2;//in meter
d=20;// in cm
d=d*10^-2;//in meter
D=35;// in cm;
D=D*10^-2;//in meter
r1=d/2;
r2=D/2;
rho=8000;// in ohm-cm
rho=80;// in ohm-m
// Let Insulation resistance of the liquid resistor = Ir
Ir=[rho/(2*%pi*l)]*log(r2/r1);
disp(" Insulation resistance of the liquid resistor is : "+string(Ir)+" ohm")
```

Scilab code Exa 2.39 `Resistivity of dielectric in a cable`

```
//Exa2.39
clc;
clear;
close;
format('v',11)
//given data
R_desh=1820;// in M ohm
R_desh=R_desh*10^6;// in ohm
d1=1.5;// in cm
d1=d1*10^-2;// in meter
d2=5;// in cm
d2=d2*10^-2;// in meter
l=3000;// in meter
r1=d1/2;
```

```
r2=d2/2;

rho= (2*%pi*l*R_desh)/log(r2/r1);
disp("Resistivity of dielectric is : "+string(rho)+"
    ohm meter")
```

Scilab code Exa 2.40 Insulation resistance

```
//Exa2.40
clc;
clear;
close;
format('v',9)
// given data
// First Case:
r1=1.5/2;// in cm
// let radius thickness of insulation = r1_t
r1_t=1.5;// in cm
r2=r1+r1_t;
R_desh=500;// in M ohm
R_desh=R_desh*10^6;// in ohm
// Second case:
r1_desh=r1;// in cm (as before)
// let radius thickness of insulation = r2_t
r2_t=2.5;// in cm
r2_desh=r1+r2_t;
// since Insulation resistance , R_desh= sigma/(2*
    %pi*l)*log(r2/r1) and
//                               R1_desh= sigma/(2*
    %pi*l)*log(r2_desh/r1_desh)
// Dividing R1_desh by R1, We get
// R1_desh/R_desh = log(r2_desh/r1_desh)/log(r2/r1)
// Let R = R1_desh/R_desh, Now
R= log(r2_desh/r1_desh)/log(r2/r1);
R1_desh=R*R_desh;
```

```
disp("New insulation resistance is : "+string(R1_desh*10^-6)+" M ohm");
```

Scilab code Exa 2.41 Insulation resistance and resistance of copper conductor

```
//Exa2.41
clc;
clear;
close;
// given data
t1=20;// in degree C
t2=36;// in degree C
alpha_20=0.0043;// in per degree C  (Temperature Coefficient)
InsulationResistance=480*10^6;// in ohm
copper_cond_res=0.7;// in ohm  (copper conductor resistance)
l=500*10^-3;// in kilo meter (length)
R1_desh=InsulationResistance * l;// in ohm

// From Formula log(R2_desh)= log(R1_desh-K*(t2-t1))
// K= 1/(t2-t1)*log(R1_desh/R2_desh)
// since when t2-t1=10 degree C and R1_desh/R2_desh=2

K=1/10*log(2);

// (i) Insulation resistance at any temperature t2, R2_desh is given by
  logR2_desh= log(R1_desh)-(t2-t1)/10* log(2);
  R2_desh= %e^logR2_desh

  disp("(i) Insulation resistance at any temperature : "+string(R2_desh*10^-6)+" Mega ohm");

```

```
// (ii)
    R_20= copper_cond_res/l;// in ohm
    R_36=R_20*[1+alpha_20*(t2-t1)];

    disp("Resistance at 36 degree C is : "+string(
       R_36)+" ohm")
```

Chapter 3

Semiconductor

Scilab code Exa 3.1 Velocity of electron

```
//Exa3.1
clc;
clear;
close;
// given data
E=2.1;//in eV
E=E*1.602*10^-19;// in J
m=9.107*10^-31;// in kg (mass of electron)
// Formula E=1/2*m*v^2
v=sqrt(2*E/m);
disp(" Velocity of electron at Fermi−level is : "+
   string(v)+" m/s")
```

Scilab code Exa 3.2 Relaxation time resistivity of conductor and velocity of elect

```
//Exa3.2
clc;
clear;
```

```
close;
// given data
E=5.5;// in eV; (Fermi energy)
E=E*1.6*10^-19;// in J
miu_e=7.04*10^-3; //in m^2/V-s  (Mobility of
    electrons)
n=5.8*10^28 ; // in /m^3   (Number of conduction
    electrons/m^3)
e=1.6*10^-19; // in coulomb
m=9.1*10^-31;//in kg
//(i) Relaxation time,
tau=miu_e/e*m;
disp("(i) Relaxation time is : "+string(tau)+"
    second");
sigma=(n*e*miu_e);
//(ii) Resistivity of conductor,
rho=1/sigma;
disp("(ii) Resistivity of conductor is : "+string(
    rho)+" ohm-meter");
// (iii) Let Velocity of electrons with fermi energy
     = v
v=sqrt(2*E/m);
disp("(iii) Velocity of electron with Fermi-level is
     : "+string(v)+" m/s");
```

Scilab code Exa 3.3 Electron and hole density

```
//Exa3.3
clc;
clear;
close;
// given data
n_i=2.5*10^13;// in /cm^3
rho=0.039;// in ohm-cm
sigma_n=1/rho;
```

```
e=1.602*10^-19;// in C
miu_e=3600;// in cm^2/V-s
//since sigma_n = n*e*miu_e = N_D*e*miu_e
N_D=sigma_n/(e*miu_e);
n=N_D;// (approx)
disp("Concentration of electrons is : "+string(n)+" /cm^3");
p=n_i^2/n;
disp("Concentration of holes is : "+string(p)+" /cm^3");
```

Scilab code Exa 3.4 Donar atom concentration mobile electron concentration hole co

```
//Exa3.4
clc;
clear;
close;
// given data
SiliconAtom=5*10^22;// unit less (Number of silicon atom)
DonorImpurity=1/10^6;
n_i=1.45*10^10;// in cm^-3
e=1.602*10^-19;// in C
miu_e=1300;// taking miu_e for Si as 1300 cm^2/V-s
// (i) Donor atom concentraion
// Formula N_D= Number of silicon atoms/cm^3 * donor impurity
N_D=SiliconAtom*DonorImpurity;
disp("(i) Donor atom concentration is : "+string(N_D)+" per cm^3");

// (ii) Mobile electron concentration
n=N_D; // (approx.)
disp("(ii) Mobile electron concentration is : "+string(n)+" per cm^3");
```

```
// (iii) Hole concentration
p=n_i^2/N_D;
disp("(iii) Hole concentration is : "+string(p)+" /cm^3");

//(iv) conductivity of doped silicon sample
sigma=n*e*miu_e;
disp("(iv) conductivity of doped silicon sample is : "+string(sigma)+" S/cm");

rho=1/sigma;
//(v) resistance of given semiconductor
l=0.5;// in cm
a=(50*10^-4)^2
R=rho*l/a;
disp("Resistance of give semiconductor is : "+string(R)+" ohm");
```

Scilab code Exa 3.5 Concentration of hole in si

```
//Exa3.5
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;// (approx)
p=n_i^2/n;
// let Ratio of electron to hole concentration = r
r=n/p;
disp("Ratio of electron to hole concentration is : "+string(r));
```

Scilab code Exa 3.6 Conductivity and resitivity of an intrinsic semiconductor

```
//Exa3.6
clc;
clear;
close;
// given data
n_i=2.5*10^13;// in cm^3
e=1.6*10^-19;// in coulomb
miu_h=1800;// in cm^2/V-s
miu_e=3800;// in cm^2/V-s
sigma_i=n_i*e*(miu_e+miu_h);
disp("Intrinsic conductivity is : "+string(sigma_i)+
    " /ohm-cm");
rho_i=1/sigma_i;
disp("Intrinsic resistiviry is : "+string(rho_i)+"
    ohm-cm")
```

Scilab code Exa 3.7 Density of electron and drift velocity of holes and electrons

```
//Exa3.7
clc;
clear;
close;
// given data
rho_i=0.47;// in ohm-meter
sigma_i=1/rho_i;
miu_e=0.39;// in m^2/V-s
miu_h=0.19;// in m^2/V-s
e=1.6*10^-19;// in C

// since sigma_i=n_i*e*(miu_e+miu_h);
```

```
n_i=sigma_i/(e*(miu_e+miu_h));
// so Density of electrons = Intrinsic Concentration
    , n_i
disp("Density of electons is :"+string(n_i)+" /m^3")
    ;
E=10^4;// in V/m
v_n=miu_e*E;
disp("Drift velocity of electrons is : "+string(v_n)
    +" m/s");
v_h=miu_h*E;
disp("Drift velocity of holes is : "+string(v_h)+" m
    /s");
```

Scilab code Exa 3.8 Conductivity of Si

```
//Exa3.8
clc;
clear;
close;
// given data
n_i=1.5*10^10;// in /cm^3
miu_e=1300;// in cm^2/V-s
miu_h=450;// in cm^2/V-s
e=1.6*10^-19;// in C (charge of electrons)
sigma_i=n_i*e*(miu_e+miu_h);
disp("Conductivity of silicon (intrinsic) is : "+
    string(sigma_i)+" /ohm-cm");
N_A=10^18;// in /cm^3
disp("conductivity of the resulting P-type silicon
    semiconductor")
sigma_p=e*N_A*miu_h;
disp(string(sigma_p)+" /ohm-cm");
```

Scilab code Exa 3.9 Find conductivity of intrinsic Ge

```
//Exa3.9
clc;
clear;
close;
// given data
n_i=2.5*10^13;// in /m^3
miu_e=3800;// in cm^2/V-s
miu_h=1800;// in cm^2/V-s
e=1.6*10^-19;// in C (charge of electrons)
sigma_i=n_i*e*(miu_e+miu_h);
disp("Intrinsic conductivity is : "+string(sigma_i)+
    " /ohm-cm");
// Let Number of germanium atoms/cm^3 = no_g
no_g=4.41*10^22;
// since Donor impurity = 1 donor atom / 10^7
    germanium atoms, so
DonorImpurity=10^-7;
N_D=no_g*DonorImpurity;
n=N_D; // (approx)
p=n_i^2/N_D;
// so
sigma_n=e*N_D*miu_e;
disp("conductivity in N-type germanium semiconductor
     is : "+string(sigma_n)+" /ohm-cm");
```

Scilab code Exa 3.10 Electron and hole drift velocity conductivity of intrinsic Ge

```
//Exa3.10
clc;
clear;
close;
// given data
e=1.6*10^-19;//in C
```

```
miu_e=.38;// in m^2/V-s
miu_h=.18;// in m^2/V-s
l=25;// in mm (length)
l=l*10^-3;// in m
w=4;// in mm (width)
w=w*10^-3;// in m
t=1.5;// in mm (thickness)
t=t*10^-3;// in m
V=10;// in V
l=25;// in mm
l=l*10^-3;//in m
E=V/l;
//(i)
v_e=miu_e*E;
v_h=miu_h*E;
disp("Electron drift velocity is : "+string(v_e)+" m
    /s");
disp("Hole drift velocity is : "+string(v_h)+" m/s")
    ;
n_i=2.5*10^19;//in /m^3
//(ii)
sigma_i=n_i*e*(miu_e+miu_h);
disp("Intrinsic conductiviry of Ge is : "+string(
    sigma_i)+" /ohm-cm");
//(iii)
a=w*t;
I=sigma_i*E*a;// in amp
I=I*10^3;// in m A
disp("Total current is : "+string(I)+" mA");
```

Scilab code Exa 3.11 Diffusion coefficient of electron and hole

```
//Exa3.11
clc;
clear;
```

```
close;
// given data
k_desh=1.38*10^-23;// in J degree^-1
e=1.602*10^-19;// in C
miu_e=3600;// in cm^2/V-s
miu_h=1700;// in cm^2/V-s
T=300;// in K
D_e=miu_e*k_desh*T/e;
disp("Diffusion constant of electrons is : "+string(
    D_e)+" cm^2/s");
D_h=miu_h*k_desh*T/e;
disp("Diffusion constant of holes is : "+string(D_h)
    +" cm^2/s");
```

Scilab code Exa 3.12 Hall effect in semiconductor

```
//Exa3.12
clc;
clear;
close;
// given data
e=1.6*10^-19;// in coulomb
Resistivity=9*10^-3;// in ohm-m
R_H=3.6*10^-4;// in m^3 coulomb^-1 (Hall
    Coefficient)
sigma=1/Resistivity;
rho=1/R_H;
n=rho/e;
disp("Density of charge carriers is : "+string(n)+"
    /m^3");
miu=sigma*R_H;
disp("Mobility is : "+string(miu)+" m^2/V-s");
```

Scilab code Exa 3.13 Current density

```
//Exa3.13
clc;
clear;
close;
// given data
E_x=100;// in V/m
e=1.6*10^-19;// in C
R_H=0.0145;// in m^3/coulomb
miu_n=0.36;// in m^2/volt-second
// Formula R_H=1/(n*e)
n=1/(R_H*e);
sigma=n*e*miu_n;
J=sigma*E_x;
disp("Current density is : "+string(J)+" A per m^2")
    ;
```

Scilab code Exa 3.14 Value of hall coefficient

```
//Exa3.14
clc;
clear;
close;
// given data
Resistivity=9;// in milli-ohm-m
Resistivity=9*10^-3;// in ohm-m
miu=0.03;// in m^2/V-s
sigma=1/Resistivity;
R_H=miu/sigma;
disp("Half coefficient is : "+string(R_H)+" m^3/C");
```

Scilab code Exa 3.15 Magnitude of Hall voltage

```
//Exa3.15
clc;
clear;
close;
// given data
E_x=5;// in V/cm
miu_e=3800;// in cm^2/V-s
B_z=0.1;// in Wb/m^2
d=4;// in mm
d=d*10^-3;// in m
v=miu_e*E_x;//in cm/second
v=v*10^-2;// in m/second
V_H=B_z*v*d;// in V
V_H=V_H*10^3;// in m V
disp("Hall voltage is : "+string(V_H)+" mV");
```

Scilab code Exa 3.16 Mobility of holes

```
//Exa3.16
clc;
clear;
close;
// given data
rho=200;// in Kilo ohm-cm
rho=rho*10^-2;// in kilo ohm m
rho=rho*10^3;// in ohm meter
sigma=1/rho;
V_H=50;// in mV
V_H=V_H*10^-3;//in V
I=10;// in miu A
I=I*10^-6;//in A
B_z=0.1;// in Wb/m^2
w=3;//in mm
w=w*10^-3;//in meter
R_H=V_H*w/(B_z*I);
```

```
disp("Mobility of holes in p-type silicon bar is : ")
miu_h=sigma*R_H;
disp(string(miu_h)+" m^2/V-s");
```

Scilab code Exa 3.17 Hall voltage

```
//Exa3.17
clc;
clear;
close;
// given data
N_D=1*10^21;// in /m^3
B_Z=0.2;// in T
J=600;// in A/m^2
n=N_D;
d=4;//in mm
d=d*10^-3;// in meterr
e=1.6*10^-19;// in C  (electron charge)
// Formula  V_H*w/(B_Z*I) = 1/(n*e) , hence V_H=B_Z*I/(n*e*w)
// where I=J*w*d
// putting I=J*w*d in V_H=B_Z*I/(n*e*w), we get
V_H=B_Z*J*d/(n*e);// in V
V_H=V_H*10^3;// in mV
disp("Hall Voltage is : "+string(V_H)+" mV");
```

Scilab code Exa 3.18 Hall voltage

```
//Exa3.18
clc;
clear;
close;
```

```
// given data
w=0.1;// in mm
B_Z=0.6;// in T
R_H=3.8*10^-4;// in m^3/C
I=10;// in mA
I=I*10^-3;//in A
V_H=R_H*B_Z*I/w;// in V
V_H=V_H*10^6;// in V
disp("Hall voltage is : "+string(V_H)+" micro volt")
    ;
```

Scilab code Exa 3.19 Density and mobility of carrier

```
//Exa3.19
clc;
clear;
close;
// given data
Resistivity=9.23*10^-3;// in ohm-m
R_H=3.84*10^-4;//in m^3/C   (Hall Coefficient)
sigma=1/Resistivity;
rho=1/R_H;
e=1.6*10^-19;// in C (electron charge)
n=rho/e;
disp("Density of charge carriers is : "+string(n)+"
    /m^2");
miu=sigma*R_H;
disp("Mobility is : "+string(miu)+" m^2/V-s")
```

Scilab code Exa 3.20 Hll angle

```
//Exa3.20
clc;
```

```
clear;
close;
// given data
B=0.48;// in Wb/m^2
R_H=3.55*10^-4;// in m^3/C
Resistivity=.00912;// in ohm
sigma=1/Resistivity;
theta_H=atand(sigma*B*R_H);
disp("Hall angle is : "+string(theta_H)+" degree")
```

Scilab code Exa 3.21 New position of fermi level

```
//Exa3.21
clc;
clear;
close;
// given data
T=27;// in degree C
T=T+273;// in K
// Let E_C - E_F =E_CF
E_CF=0.3;// in eV
// Formula E_C - E_F = k*T*log(n_C/N_D)
// Let log(n_C/N_D) = L, so
L=E_CF/T;
T_desh=55;// in degree C
T_desh=T_desh+273;// in K
//At temperature T_desh
new_fermi_level= T_desh*L;  // where L=log(n_C/N_D)
disp("The new position of Fermi Level is : "+string(
   new_fermi_level)+" V");
```

Scilab code Exa 3.22 Potential barrier

```
//Exa3.22
clc;
clear;
close;
// given data
N_A=8*10^14;// in /cm^3
N_D=N_A;
n_i=2*10^13;// in /cm^3
k=8.61*10^-5;// in eV/K
T=300;// in K
V_0=k*T*log(N_D*N_A/n_i^2);
disp("Potential barrier is : "+string(V_0)+" V");
```

Scilab code Exa 3.23 Resistance level

```
//Exa3.23
clc;
clear;
close;
// given data
// (i) when
I_D=2;// in mA
I_D=I_D*10^-3;// in A
V_D=0.5;// in V
R1=V_D/I_D;
disp("Resistace is : "+string(R1)+" ohm");
// (ii) when
I_D=20;// in mA
I_D=I_D*10^-3;// in A
V_D=0.8;// in V
R2=V_D/I_D;
disp("Resistace is : "+string(R2)+" ohm");
// (ii) when
I_D=-1;// in miu A
I_D=I_D*10^-6;// in A
```

```
V_D=-10;// in V
R3=V_D/I_D;// in ohm
R3=R3*10^-6;// in M ohm
disp("Resistace is : "+string(R3)+" M ohm");
```

Scilab code Exa 3.24 Fraction of the total number of electron

```
//Exa3.24
clc;
clear;
close;
format('v',12)
// given data
E_G=0.72;// in eV
E_F=E_G/2;// in eV
k=8.61*10^-5; // in eV/K
T=300;// in K
// Formula n_C/n = 1/1+%e^(E_G-E_F)/k*T
// Let n_C/n = N
N=1/(1+%e^((E_G-E_F)/(k*T)));

disp("Fraction of the total number of electrons (
   conduction band as well as valence band) : "+
   string(N));
```

Scilab code Exa 3.25 Current flowing

```
//Exa3.25
clc;
clear;
close;
format('v',3)
// given data
```

```
I_0=.15;// in micro amp
I_0=I_0*10^-6;// in A
V=0.12;// in V
V_T=26;// in mV
V_T=V_T*10^-3;// in V
I=I_0*(%e^(V/V_T)-1);// in amp
I=I*10^6;// in micro amp
disp("Large reverse bias current is : "+string(I)+"
    micro amp");
```

Scilab code Exa 3.26 Forward voltage

```
//Exa3.26
clc;
clear;
close;
format('v',5)
// given data
I=.01;// in A
I_0=2.5*10^-6;// in  amp
nita=2;// for silicon
V_T=26;// in mV
V_T=V_T*10^-3;// in V
// Formula I=I_0*(%e^(V/(nita*V_T))-1);
V=nita*V_T*log(I/I_0+1);
disp("Forward voltage is : "+string(V)+" V") ;
```

Scilab code Exa 3.27 Reverse saturation current density

```
//Exa3.27
clc;
clear;
close;
```

```
// given data
N_D=10^21;// in m^-3
N_A=10^22;// in m^-3
D_e=3.4*10^-3;// in m^2/s
D_h=1.2*10^-3;// in m^2/s
L_e=7.1*10^-4;// in m
L_h=3.5*10^-4;// in m
n_i=1.602*10^16;// in /m^3
e=1.6*10^-19;// in C (electron charge)
// Formula  I_0=a*e*[D_h/(L_h*N_D) + D_e/(L_e*N_A)]*n_i^2
//and
// Reverse saturation current density = I_0/a = [D_h/(L_h*N_D) + D_e/(L_e*N_A)]*e*n_i^2 , So
CurrentDensity= [D_h/(L_h*N_D) + D_e/(L_e*N_A)]*e*n_i^2;// in A
CurrentDensity=CurrentDensity*10^6;// in micro A
disp("Reverse saturation current density is : "+string(CurrentDensity)+"  micro amp");
```

Scilab code Exa 3.28 Junction width

```
//Exa3.28
clc;
clear;
close;
// given data'
format('v',13)
N_D=10^17*10^6;// in m^-3
N_A=0.5*10^16*10^6;// in atoms/m^3
epsilon_r=10;// in F/m
epsilon_o=8.85*10^-12;// in F/m
epsilon=epsilon_r*epsilon_o;
e=1.602*10^-19;// in C (electron charge)
// (i) when no external voltage is applied i.e.
```

```
V=0;
V_B=0.7;// in V
W=sqrt(2*epsilon*V_B/e*(1/N_A+1/N_D));
disp("Junction width is : "+string(W)+" m");
// (ii) when external voltage of -10 V is applied i.
    e.
V=-10;// in V
V_o=0.7;// in V
V_B=V_o-V;
W=sqrt(2*epsilon*V_B/e*(1/N_A+1/N_D));
disp("Junction width is : "+string(W)+" m");

// Note: Answer in the book is wrong
```

Chapter 4

Bipolar Junction And Field Effect Transistors

Scilab code Exa 4.1 `Resistance between gate and source`

```
//Exa 4.1
clc;
clear;
close;
//given data :
format('v',11)
VGS=10;//in Volt
IG=0.001;//in uAmpere
IG=IG*10^-6;//in Ampere
RGS=VGS/IG;//in Ohm
disp(RGS*10^-6,"Resistance between gate and source
   in Mohm : ");
```

Scilab code Exa 4.2 `AC drain resistance of the JFET`

```
//Exa 4.2
```

```
clc;
clear;
close;
//given data :
delVDS=1.5;//in Volt
delID=120;//in uAmpere
delID=delID*10^-6;//in Ampere
rd=delVDS/delID;//in Ohm
disp(rd*10^-3,"AC drain Resistance of JFET in Kohm :
    ");
```

Scilab code Exa 4.3 `Transconductance`

```
//Exa 4.3
clc;
clear;
close;
//given data :
ID2=1.5;//in mAmpere
ID1=1.2;//in mAmpere
delID=ID2-ID1;//in Ampere
VGS1=-4.25;//in Volt
VGS2=-4.10;//in Volt
delVGS=VGS2-VGS1;//in Volt
gm=delID/delVGS;//in Ohm
disp(gm,"Transconductance in mA/V : ");
disp(gm*10^3,"Transconductance in uS : ");
```

Scilab code Exa 4.4 `AC drain resistance transconductance and amplification factor`

```
//Exa 4.4
clc;
clear;
```

```
close;
//given data :
VDS1=5;//in Volt
VDS2=12;//in Volt
VDS3=12;//in Volt
VGS1=0;//in Volt
VGS2=0;//in Volt
VGS3=-0.25;//in Volt
ID1=8;//in mAmpere
ID2=8.2;//in mAmpere
ID3=7.5;//in mAmpere
//AC drain resistance
delVDS=VDS2-VDS1;//in Volt
delID=ID2-ID1;//in mAmpere
rd=delVDS/delID;//in Kohm
disp(rd,"AC Drain resistance in Kohm : ");
//Transconductance
delID=ID3-ID2;//in mAmpere
delVGS=VGS3-VGS2;//in Volt
gm=delID/delVGS;//in mA/V or mS
disp(gm,"Transconductance in mA/V : ");
//Amplification Factor
meu=rd*1000*gm*10^-3;//unitless
disp(meu,"Amplification Factor : ");
```

Scilab code Exa 4.5 Transconductance

```
//Exa 4.5
clc;
clear;
close;
//given data :
VP=-4.5;//in Volt
IDSS=10;//in mAmpere
IDS=2.5;//in mAmpere
```

```
//Formula : IDS=IDSS*[1-VGS/VP]^2
VGS=VP*(1-sqrt(IDS/IDSS));//in Volt
gm=(-2*IDSS*10^-3)*(1-VGS/VP)/VP;//in mA/V or mS
disp(gm*1000,"Transconductance in mA/V : ");
```

Scilab code Exa 4.6 Calculate VGS

```
//Exa 4.6
clc;
clear;
close;
//given data :
gm=10;//in mS
gm=gm*10^-3;//in S
IDSS=10;//in uAmpere
IDSS=IDSS*10^-6;//in Ampere
//VGS(OFF):VGS=VP
//Formula : gm=gmo=-2*IDSS/VP=-2*IDSS/VG(Off)
VGS_OFF=-2*IDSS/gm;//in Volt
disp(VGS_OFF*1000,"VGS(OFF) in mV : ");
```

Scilab code Exa 4.7 Minimum value of VDS

```
//Exa 4.7
clc;
clear;
close;
//given data :
VP=-4;//in Volt
VGS=-2;//in Volt
IDSS=10;//in mAmpere
IDSS=IDSS*10^-3;//in Ampere
//Formula : ID=IDSS*[1-VGS/VP]^2
```

```
ID=IDSS*[1-VGS/VP]^2;//in Ampere
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 : VDS(min) = "+string(VP)+" Volt");
```

Scilab code Exa 4.8 `ID gmo and gm`

```
//Exa 4.8
clc;
clear;
close;
//given data :
IDSS=8.7;//in mAmpere
IDSS=IDSS*10^-3;//in Ampere
VP=-3;//in Volt
VGS=-1;//in Volt
//ID
ID=IDSS*[1-VGS/VP]^2
disp(ID*1000,"Drain current ID in mA : ");
//gmo
gmo=-2*IDSS/VP;//in S
disp(gmo*1000,"Transconductance for VGS=0V in mA/V or mS : ");
//gm
gm=gmo*(1-VGS/VP);//in S
disp(gm*1000,"Transconductance in mA/V or mS : ");
```

Scilab code Exa 4.9 `Id and gm`

```
//Exa 4.9
clc;
clear;
```

```
close;
//given data :
IDSS=8.4;//in mAmpere
IDSS=IDSS*10^-3;//in Ampere
VP=-3;//in Volt
VGS=-1.5;//in Volt
//ID
ID=IDSS*[1-VGS/VP]^2
disp(ID*1000,"Drain current ID in mA : ");
//gmo
gmo=-2*IDSS/VP;//in S
disp(gmo*1000,"Transconductance for VGS=0V in mA/V
   or mS : ");
gm=gmo*(1-VGS/VP);//in S
disp(gm*1000,"Transconductance in mA/V or mS : ");
```

Scilab code Exa 4.10 `gm at IDS`

```
//Exa 4.10
clc;
clear;
close;
//given data :
VP=-4.5;//in Volt
IDSS=9;//in mAmpere
IDSS=IDSS*10^-3;//in Ampere
IDS=3;//in mAmpere
IDS=IDS*10^-3;//in Ampere
//Formula : IDS=IDSS*[1-VGS/VP]^2
VGS=VP*(1-sqrt(IDS/IDSS));//in Volt
disp(VGS,"ID=3mA at VGS in Volt :");
gm=(-2*IDSS)*(1-VGS/VP)/VP;//in mA/V or mS
disp(gm*1000,"Transconductance in mA/V or mS: ");
```

Scilab code Exa 4.11 Drain current

```
//Exa 4.11
clc;
clear;
close;
//given data :
ID_on=5;//in mAmpere
VGS_on=8;//in Volt
VGS=6;//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,"Drain current in mA : ");
```

Chapter 5

Magnetic Properties Of Materials

Scilab code Exa 5.1 Hysteresis loss

```
//Exa 5.1
clc;
clear;
close;
// given data
Area_hysteresis_curve=9.3;//in cm^2
Cordinate1_1cm=1000;//in AT/m
Cordinate2_1cm=0.2;//in T
//Part (i)
hysteresis_loss=Area_hysteresis_curve*Cordinate1_1cm
   *Cordinate2_1cm;//in J/m^3/cycle
disp(hysteresis_loss,"Hysteresis loss/m^3/cycle in J
   /m^3/cycle: ");
//Part (ii)
f=50;//in Hz
H_LossPerCubicMeter=hysteresis_loss*f;//in Watts
disp(H_LossPerCubicMeter*10^-3,"Hysteresis loss Per
   Cubic Meter in KWatts :");
```

Scilab code Exa 5.2 Hysteresis loss

```
//Exa 5.2
clc;
clear;
close;
format('v',11)
// given data
Area_hysteresis_loop=93;//in cm^2
scale1_1cm=0.1;//in Wb/m^2
scale2_1cm=50;//in AT/m

hysteresis_loss=Area_hysteresis_loop*scale1_1cm*
    scale2_1cm;//in J/m^3/cycle
disp(hysteresis_loss,"Hysteresis loss/m^3/cycle in J
    /m^3/cycle: ");

f=65;//unit less
V=1500*10^-6;// in m^3
P_h=hysteresis_loss*f*V;
disp("Hysteresis loss is : "+string(P_h)+" W");
```

Scilab code Exa 5.3 Loss of energy

```
//Exa 5.3
clc;
clear;
close;
format('v', 11)
// given data
nita=628;// in J/m^3
B_max=1.3;// in Wb/m^2
```

```
f=25;// in Hz
ironMass=50;// in kg
densityOfIron=7.8*10^3;// in kg/m^3
V=ironMass/densityOfIron;
x=12.5;// in AT/m
y=0.1;// in T
// formula Hysteresis loss/second = nita*B_max^1.6*f*V
H_Loss_per_second = nita*B_max^1.6*f*V ;// in J/s
H_Loss_per_second=floor(H_Loss_per_second);
H_Loss_per_hour= H_Loss_per_second*60*60;// in J
disp("Hysteresis Loss per hour is : "+string(H_Loss_per_hour)+" J");
// Let Hysteresis Loss per m^3 per cycle = H1
H1=nita*B_max^1.6;
// formula  hysteresis loss/m^3/cycle = x*y*area of B-H loop
Area_of_B_H_loop=H1/(x*y);
Area_of_B_H_loop=floor(Area_of_B_H_loop);
disp("Area of B-H loop is : "+string(Area_of_B_H_loop)+" cm^2");
```

Scilab code Exa 5.4 Loss per kg in a specimen

```
//Exa 5.4
clc;
clear;
close;
// given data
H_L_per_M_Cube_per_C=380;// in W-S
f=50;// unit less
density=7800;// in kg/m^3
V=1/density;// in m^3
// formula Hysteresis loss = Hysteresis loss/m^3/cycle * f * V
```

```
P_h=H_L_per_M_Cube_per_C * f * V;
disp("Hysteresis loss is : "+string(P_h)+" W");
```

Scilab code Exa 5.5 `Eddy current loss`

```
//Exa 5.5
clc;
clear;
close;
// given data
P_e1=1600;// in watts
B_max1=1.2;// in T
f1=50;// in Hz
B_max2=1.5;// in T
f2=60;// in Hz
// P_e propotional to B_max^2*f^2, so
P_e2=P_e1*(B_max2/B_max1)^2*(f2/f1)^2
disp("Eddy current loss is : "+string(P_e2)+" watts"
   );
```

Chapter 6

Dielectric Properties Of Materials

Scilab code Exa 6.1 `Element of parallel RC circuit`

```
//Exa 6.1
clc;
clear;
close;
// given data
epsilon_r=2.5;
epsilon_o=8.854*10^-12;
d=.2*10^-3;// in m
A=20*10^-4;// in m^2
omega=2*%pi*10^6;// in radians/s
f=10^6;
tan_delta=4*10^-4;
C=epsilon_o*epsilon_r*A/d;// in F
disp("Capicitance is : "+string(C*10^12)+" miu miu F ");
// Formula P=V^2/R, so
// R=V^2/P and P= V^2*2*%pi* f * C * tan delta , putting the value of P, we get
R=1/(2*%pi*f*C*tan_delta);// in ohm
```

```
disp("The element of parallel R-C circuit is : "+
    string(R*10^-6)+" M ohm");
```

Scilab code Exa 6.2 Charge sensitivity

```
//Exa 6.2
clc;
clear;
close;
// given data
g=0.055;// in V-m/N
t=2*10^-3;// in m
P=1.25*10^6;// in N/m^2
epsilon=40.6*10^-12;// in F/m
V_out=g*t*P;
disp("Output voltage is : "+string(V_out)+" V");
// Formula Charge Sensivity=epsilon_o*epsilon_r*g=
    epsilon*g
ChargeSensivity=epsilon*g;
disp("Charge Sensivity is : "+string(ChargeSensivity
    )+" C/N");
```

Scilab code Exa 6.3 Force required to develop a voltage

```
//Exa 6.3
clc;
clear;
close;
// given data
V_out=150;// in V
t=2*10^-3;// in m
g=0.05;// in V-m/N
A=5*5*10^-6;// in m^2
```

```
F=V_out*A/(g*t);// in N
disp("Force applied is : "+string(F)+" N")
```

Scilab code Exa 6.4 Charge and its capacitance

```
//Exa 6.4
clc;
clear;
close;
// given data
g=12*10^-3;// in V-m/N
t=1.25*10^-3;// in m
A=5*5*10^-6;// in m^2
F=3;// in N
ChargeSensitivity=150*10^-12;// in C/N
P=F/A;
V_out=g*t*P;// in V
Q=ChargeSensitivity*F;
disp("Total charge developed is : "+string(Q)+" C");
// Formula C=Q/V;
C=Q/V_out;
disp("Capacitance is : "+string(C*10^12)+" miu miu F");

// Note: Answer in the Book is wrong
```