Scilab Textbook Companion for Fundamentals Of Engineering Electromagnetics by S. Bhooshan[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.

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Chapter 1

Scalars and vectors

Scilab code Exa 1.1 The density of the material

```
clc;
clear;
format('v',6);
m1=10/2.2;        //conversion from lbs to kg
m2=9.221;
M=m1+m2;
v1=1.233;
v2=2.555;
V=v1+v2;
c=0.12*V;         //contraction
Vf=V-c;           //final volume
D=M/Vf;
//format('e',9);
disp(abs(D),"at,the end,density(in kg/l)=");
```

Scilab code Exa 1.2 Diameter of a circle

```
clc;
```

```
clear;
format('v',10);
C=1600;
d=C/3.14;
disp(d,"diameter(in meter)=");
```

Scilab code Exa 1.3 Multiplication of two complex numbers

```
clc;
clear all;
format('v',11);
mod_a=sqrt(3^2+2^2);
mod_b=sqrt(15^2+3^2);
angle_a=atand(2/3);
angle_b=atand(3/15);
mod_ans=mod_a*mod_b;
angle_ans=angle_a+angle_b;
disp(angle_ans,"phase angle of ans(in degree)=",
    mod_ans,"mod of ans=");
```

Scilab code Exa 1.5 Calculations with vector addtion

```
clc;
clear;
format('e',11);
mod_B=15;
angle_B=30;
mod_A=10;
angle_A=0;
Bx=mod_B*cosd(angle_B);
By=mod_B*sind(angle_B);
Ax=mod_A*cosd(angle_A);
Ay=mod_A*sind(angle_A);
```

```
Cx=Ax+Bx;
Cy=Ay+By;
mod_C=sqrt(Cx^2+Cy^2);
angle_C=atand(Cy/Cx);
disp(angle_C,"angle_C(in degree)=",mod_C,"mod_C(in
    newton)=");
```

Scilab code Exa 1.6 Calculations with vector addtion

```

clc;
clear;
format('v',6);
mod_B=20;
angle_B=150;
mod_A=10;
angle_A=0;
Bx=mod_B*cosd(angle_B);
By=mod_B*sind(angle_B);
Ax=mod_A*cosd(angle_A);
Ay=mod_A*sind(angle_A);
Cp=Ax+Bx;              //parallel to A
Cv=Ay+By ;             //perpendicular to A
disp(Cv,"perpendicular to A,Cv(in Newton)=",Cp,"
    parallel to A,Cp(in Newton)=");
```

Scilab code Exa 1.7 Calculations with vector addtion

```
clc;
clear;
format('v',11);
A=[1 3 5];
B=[0 5 0];
```

```
C=A-B;
disp(C,"difference(in newton)=");
```

Scilab code Exa 1.8 The work done by a constant force

```
clc;
clear;
format('v',11);

//part a
F=[100*cosd(30) 100*sind(30)];
d=[100 0];
W=F.*d;
disp(W(1),"work done(in joule)=");

//part b
W=integrate('10*x*cosd(30)','x',0,100);
disp(W,"work done(in joule)=");
```

Scilab code Exa 1.11 Cross products of orthogonal unit vectors

```
clc;
clear;
format('v',11);
A=[2 4 0];
B=[1 7 0];
mod_A=sqrt(A(1)^2+A(2)^2+A(3)^2);
mod_B=sqrt(B(1)^2+B(2)^2+B(3)^2);
U1=A(1,2)*B(1,3)-A(1,3)*B(1,2);
U2=A(1,3)*B(1,1)-A(1,1)*B(1,3);
U3=A(1,1)*B(1,2)-A(1,2)*B(1,1);
U=[U1 U2 U3];
disp(U,"A*B=");
```

```
A.B=A(1)*B(1)+A(2)*B(2)+A(3)*B(3);          //dot product
theta=acosd(A.B/(mod_A*mod_B));             //angle between A and B
mod=mod_A*mod_B*sind(theta);
disp(mod,"mod_(A*B)");
disp("and is perendicular to A and B both","hence |A*B|=|A|*|B|*sin(theta)");
```

Scilab code Exa 1.12 Cross products in rectangular coordinates

```
clc;
clear;
format('v',11);
A=[4 3 0];
B=[3 4 0];
mod_A=sqrt(A(1)^2+A(2)^2+A(3)^2);
mod_B=sqrt(B(1)^2+B(2)^2+B(3)^2);
U1=A(1,2)*B(1,3)-A(1,3)*B(1,2);
U2=A(1,3)*B(1,1)-A(1,1)*B(1,3);
U3=A(1,1)*B(1,2)-A(1,2)*B(1,1);
U=[U1 U2 U3];
disp(U,"A*B=");
A.B=A(1)*B(1)+A(2)*B(2)+A(3)*B(3);          //dot product
theta=acosd(A.B/(mod_A*mod_B));             //angle between A and B
mod=mod_A*mod_B*sind(theta);
disp(mod,"mod_(A*B)");
disp("and is perendicular to A and B both","hence |A*B|=|A|*|B|*sin(theta)");
```

Chapter 2

Coordinate Systems and Fields

Scilab code Exa 2.1 The pressure at height

```
clc;
clear;
format('v',4)                                //formating the number display
h=(log(0.9))/(-0.0001193);                   //calculating the height
disp(h,'The height h at which the pressure is 9/10 of the pressure at the surface of the earth is (in meter):');       //displaying the height
```

Scilab code Exa 2.4 Direction cosines

```
clc;
clear;
```

```
format('v',11);
r=[2 3 4];    //Given Position vector r
disp(r,'Given the vector r=');
modr=sqrt(2^2+3^2+4^2);    //Magnitude of the given vector r
Ax=(2/modr);    //Coeffitient in the X direction
Ay=(3/modr);    //Coeffitient in the Y direction
Az=(4/modr);    //Coeffitient in the Z direction
//Displaying the direction cosines and the angles
format('v',8)
disp('The direction cosines of the  given vector are : ');
disp(Ax,'Ax=')
disp(Ay,'Ay=')
disp(Az,'Az=')

x=[Ax Ay Az];
format('v',6)
y=acosd(x);
disp(y,'The angles that the given vector makes with the three vectors are (in Degree):')
```

Scilab code Exa 2.6 Vector equations of a straight line

```
clc;
clear;
```

```
format('v',11);
r0=[1,1,1];                //Vector ro
r1=[1,2,3];                //Vector r1
//Displaying the given points in vectorial form
disp(r0,'The given two points are: ro=');
disp(r1,'r1=');
R=r1-r0;
modR=sqrt(R(1)^2+R(2)^2+R(3)^2);                //Distance between the two given points
unit_R=R/modR;                //Unit vector along the vector from ro towards r1
p1=5*unit_R+r0;                //Point at 5cm from ro towards r1
disp(p1,'The point at distance of 5cm away from r0 and towards r1 is:p1= ');
p2=-5*unit_R+r0;
disp(p2,'The point at distance of 5cm away from r0 and away from r1 is:p2=');    //Point at 5cm from ro and away from r1
disp('Equation of the line passing through the given points:r=t(r1-r0)+r0');
disp('to find the intersection of this line with X-Y plane:z=0');
t=-1*sqrt(5)/2;
disp(t,'The value of the parameter t=');                //Displaying the equation of the line
//Computing the location of the point of intersection
x=t*unit_R(1)+r0(1);
y=t*unit_R(2)+r0(2);
```

```
p1=[x,y,0];
    // Point of intersaction with X-Y plane
disp(p1,'The point of intersection with X-Y plane:p1
    =');
disp('to find the intersection with x-z plane:y=0');
t=-1*sqrt(5);
    //The value of the parameter t
disp(t,'The value of the parameter t=');
x=t*unit_R(1)+r0(1);
z=t*unit_R(3)+r0(3);
p2=[x 0 z];
    //Point of intersection with X-Z plane
disp(p2,'The point of intersection with X-Z plane:p2
    =');
disp('to find the intersection with y-z plane:x=0');
disp('as we are getting 0=1,we can say that the line
     does not intersect with the Y-Z plane');
```

Scilab code Exa 2.7 Equation of a plane

```
clc;
clear;
format('v',6);
r0=[1,0,0];
    //Position vector ro
r1=[0,1,0];
    //Position vector r1
r2=[0,0,1];
    //Position vector r2
```

```
R1=r1-r0;
    //Postion vector from ro to r1
R2=r2-r0;
    //Position vector from ro to r2
u1=R1(1,2)*R2(1,3)-R1(1,3)*R2(1,2);
u2=R1(1,3)*R2(1,1)-R1(1,1)*R2(1,3);
u3=R1(1,1)*R2(1,2)-R1(1,2)*R2(1,1);
R=[u1,u2,u3];
    //Vector R perpendicular to the plane
mod_R=sqrt((u1)^2+(u2)^2+(u3)^2);                    //
    Magnitude of the vector R
unit_R=R/mod_R;
    //Unit vector along R
disp(unit_R,'The unit vector perpendicular to the
    given plane is')
```

Scilab code Exa 2.9 Cylindrical coordinate system

```
clc;
clear;
format('v',11);
r=[1,1,1];
    //Given point r
rho=sqrt(r(1)^2+r(2)^2);
    //Computing the rho coordinate
phi=atan(r(2)/r(1));
    //Computing phi coordinate
```

```
z=r(3);
format('v',7)
c=[rho,phi,z];
    //Coordinates in the cylindrical coordinates
disp(c,'The equivalent cylindrical coordinates of the given point are (rho, phi, z)= ');                    // Displaying the coordinates
```

Scilab code Exa 2.10 Cylindrical coordinate system

```
clc;
clear;
format('v',11);
c=[1,1,1];
    //Given point
x=c(1)*cos(c(2));
    //Computing the X coordinate
y=c(1)*sin(c(2));
    //Computing the Y coordinate
z=c(3);
    //the Z coordinate
format('v',8)
r=[x,y,z];
disp(r,'The equivalent rectangular coordinates of the given point are (x, y, z)=');            // Displying the coordinates
```

Scilab code Exa 2.12 Dot products between rectangular and cylindrical coordinate

```
clc;
clear;
format('v',11);
p=[1,1,1];
    //Given point
r=sqrt(p(1)^2+p(2)^2);
B=atan(p(2)/p(1));
z=p(3);
p=[r B z];
    //Given point in cylindrical coordinates

A=[1,1,1];
    //Given vector field


a=[cos(B) sin(B) 0;-1*sin(B) cos(B) 0;0 0
    1]*[1;1;1];                          //Given
    vector filed in cylincdrical coordinates
format('v',6)
disp(a,'the cylindrical components of the given
    vector filed:')
```

Chapter 3

Vector calculus

Scilab code Exa 3.1 The linear element

```
clc;
clear;
format('v',11);
//3.1.1
p=[1 1 1];
q=[1 1 1.001];
delta=q-p;    //as it is rectangular coordinates.
disp(delta,"linear element dl in rectangular
    coordinates=");

//3.1.2
p=[1,1,1];
q=[1,1.01,1.001];
D=q-p;
R=1;
delta=[D(1) R*D(2) D(3)]; //as it is cylindrical
    coordinates.
disp(delta,"linear element dl in cylindrical
    coordinates=");

//3.1.3
```

```
p=[1,1,1];
q=[1,1.01,1.001];
D=q-p;
R=1;
delta=[D(1) R*D(2) R*sin(1)*D(3)];    //as it is
   spherical coordinates.
disp(delta,"linear element dl in spherical
   coordinates=");
```

Scilab code Exa 3.2 The length of the straight line

```
clc;
clear;
format('v',6);
disp("x=t,y=t,z=t","the parametric equation of
   straight line is","from the given points");
phi=1;                          //by inspecton
d=[1 1 1];                      //where d=dr/dt
mod_d=sqrt(d(1)^2+d(2)^2+d(3)^2);
L=integrate('phi*mod_d','t',0,1);
disp(L,"required length=");
```

Scilab code Exa 3.4 The work done

```
clc;
clear;
format('v',6);
disp("where t varies from t=1 to t=10.","r=10t,theta
   =0,phi=0","the straight line can be characterized
    as");
disp("F(in Newton)=-103/100t^2 ar","hence,F can be
   written as ");
disp("And dr/dt=10 ar");
```

```
work_done=-103*10/100*integrate('1/t^2','t',1,10);
disp(work_done,"work_done(in Jule)=");
```

Scilab code Exa 3.5 Line Integral

```
clc;
clear;
format('v',6);
disp("the parametric equations of the straight line
    are:x=1-t,y=1-t,z=1-t for 0<=t<=1");
c1=integrate('1.5*t-1.5','t',0,1);    //using
    parametric equation
disp(c1,"the line integral is=");
```

Chapter 4

The Electric Field and Gauss Law

Scilab code Exa 4.2 The charge density

```
clc;
clear;
format('v',11);
Q=(-1.602*10^-19)*10^6;
disp(Q,"Total charge (in coulomb),Q=");
rho=Q/0.01;
disp(rho,"linear charge density (in coulomb per
   meter)=");
```

Scilab code Exa 4.3 Finding the total charge in the given region

```
clc;
clear;
format('v',11);
I1=integrate('exp(x)','x',-5,0);
I2=integrate('exp(-x)','x',0,5);
```

```
I3=integrate('exp(y)','y',-3,0);
I4=integrate('exp(-y)','y',0,3);
Q=(10^-12)*(I1+I2)*(I3+I4);
disp(Q,"total charge in coulomb=");
```

Scilab code Exa 4.5 Coulombs Law

```
clc;
clear;
format('e',11);
//case1
F=(1*10^-9)*(1*10^-9)/(4*3.14*8.85*10^-12*0.01^2); //according to coulomb's law
disp(F,"force felt by either of the charges at a distance of 1cm(in newton)=");
//case2
disp("At a distance of 10cm the force will be 100 times weeker,due to the inverse square law.");
F1=F/100;
disp(F1,"force at a distance of 10cm(in newton)=");
```

Scilab code Exa 4.6 Coulombs Law

```
clc;
clear;
format('v',11);
N=6.022*10^23/107.9;        //as atomic number of silver is 107.9
n=0.01*N;                   //1% of N
Q=n*1.602*10^-19;           //charge on the sphere
V=0.001/(10.5*10^3);          //as density of silver is 10.5*10^3kg/m^3
rho_v=Q/V;
```

```
disp(rho_v,"the volume charge density(in coulomb per cube meter)=");
F=1*10^-9*8.542/(4*3.14*8.85*10^-12*1^2);          //by coulomb's law
disp(F,"force(in newton)=");
```

Scilab code Exa 4.7 Coulombs Law

```
clc;
clear;
format('v',11);
F=0.001*9.8*0.01/1;        //by the equilibrium condition and approximation of sin(a/2)=tan(a/2)
Q=(F*4*3.14*8.85*10^-12*0.02^2)^(1/2);
disp(Q,"charge on each ball(in coulomb)=");
```

Scilab code Exa 4.8 Comparision between force of gravity and electrostatic attraction

```
clc;
clear;
format('v',11);
G=6.6726*10^-11;
Me=9.1094*10^-31;
Mp=1.6749*10^-27;
rb=.53*10^-10;
Fg=G*Me*Mp/rb^2;
Fc=(1.602*10^-19)^2/(4*3.14*8.85*10^-12*rb^2);
disp(Fg,"gravitational force(in newton)=");
disp(Fc,"electrostatic force(in newton)=");
disp(" times the gravitational force.",Fc/Fg,"the electrostatic force is ");
```

Scilab code Exa 4.10 Force due to electric field

```
clc;
clear;
format('v',11);
E=1;
q1=0.001;
q2=1;
m1=0.001;
m2=1;
F1=q1*E;
F2=q2*E;
a1=F1/m1;
a2=F2/m2;
disp(F2,"F2(in newton)=",F1,"F1(in newton)=");
disp(a2,"a2(in m/s^2)=",a1,"a1(in m/s^2)=");
```

Scilab code Exa 4.11 Electric Field

```
clc;
clear;
format('v',11);
E=1;
Q=1;
r=[Q/(E*4*3.14*8.85*10^-12)]^(1/2);
disp(r,"the required distance(in meter)=");
q=1;
F=q*E;
disp(F,"force(in newton)=");
```

Scilab code Exa 4.12 Electric Field

```
clc;
clear;
format('v',11);
r=[1 2 3];
r1=[1 1 1];
R=r-r1;
q=1*10^-9;
mod_R=sqrt(R(1)^2+R(2)^2+R(3)^2);
E=q*R/(4*3.14*8.85*10^-12*mod_R^3);
disp(E,"E(in v/m)=");
```

Scilab code Exa 4.23 Gauss Law Applied to a Charged Sphere

```
clc;
clear;
format('v',11);
Er=-110;          //as electric field has only radial
    component
Re=6350000;
Dr=8.85*10^-12*Er;
Q=Dr*4*3.14*Re^2;
disp(Q,"total charge dispersed on the earth(in
   coulomb)=");
rho_s=Q/(4*3.14*Re^2);
disp(rho_s,"surface charge density(in C/m^2)=");
```

Chapter 5

Energy and Potential

Scilab code Exa 5.1 Work done to move a charge

```
clc;
clear;
format('v',11);
Q=1*10^-9;
disp("path of the integration is along a line parallel to the x-axis as y and z are fixed with y=z=1.");
W=-Q*integrate('x','x',1,0);          //putting y=z=1.
disp(W,"work done(in joule)=");
```

Scilab code Exa 5.2 Work done to move a charge

```
clc;
clear;
format('e',11)
Q=1*10^-9;
r0=[3 5 6];
```

```
r1=[0 0 0];
R01=r1-r0;
disp("The parametric eqution of the straight line
    joining these two points:")
disp("z=6(1-t)","y=5(1-t)","x=3(1-t)");
    //using r=r0+tR01.
W=1305*Q*integrate('(1-t)^3','t',0,1);
    //using parametric equation.
disp(W,"work done(in joule)=");
```

Scilab code Exa 5.10 Motion of electron in electric field

```
clc;
clear;
format('v',11);
vin=2*10^7;
q=3*10^-6;
rin=[1 0 0];
mod_rin=sqrt(rin(1)^2+rin(2)^2+rin(3)^2);
Vin=q/(4*3.14*8.85*10^-12*mod_rin);          //
    potential at[1 0 0] due to point charge.
Pin=-1.6*10^-19*Vin;                          //
    initial potential energy.
Kin=(9.1094*10^-31*vin^2)/2;                  //
    initial kinetic energy considering me
    =9.1094*10^-31kg.
Etin=Pin+Kin;                                 //
    initial total energy'.
disp("As electron moves it slows down due to
    attraction to the charge at the origine and
    ultimately comes to rest.");
disp("computing rf","hence Etin=Etf=Pf","Kf=0","
    final kinetic enegy is zero");
Pf=Etin;
rf=-1.6*10^-19*q/(4*3.14*8.85*10^-12*Pf);
```

```
disp(rf,"rf(in meter)=");
disp("from this position the electron reverses
    motion and begins moving towards the charge at
    the origin.");
```

Scilab code Exa 5.11 Motion of electron in electric field

```
clc;
clear;
format('e',11);
vin=2*10^7;
q=3*10^-6;
rin=[1 0 0];
mod_rin=sqrt(rin(1)^2+rin(2)^2+rin(3)^2);
Vin=q/(4*3.14*8.85*10^-12*mod_rin);          //
    potential at[1 0 0] due to point charge.
Pin=-1.6*10^-19*Vin;                          //
    initial potential energy.
disp("Hence Etin must be equal to zero","When the
    electron reaches at infinite distance Pf=Kf=0.");
vin=sqrt(-Pin*2/(9.1094*10^-31));
    //considering me=9.1094*10^-31kg.
disp(vin,"vin(in meter/sec)=");
disp("Beyond this velocity the electron escapes.");
```

Chapter 6

The Electric Field and Material Media

Scilab code Exa 6.1 The total charge passing a plane

```
clc;
clear;
format('v',11)
I=1;
Q=integrate('1','t',0,1);           //as I=1
disp(Q,"Total charge passing the cross-section in 1
   sec(in coulomb)=");
```

Scilab code Exa 6.2 The total charge passing a plane

```
clc;
clear;
Q=integrate('1*exp(-3*t)','t',0,3);           //as I
   =1*e^(-3t) A
disp(Q,"Total charge passing the cross-section in 1
   sec(in coulomb)=");
```

Scilab code Exa 6.3 The current density

```
clc;
clear;
format('e',11)
I=1;
d=1*10^-3;
A=(3.14*d^2/4);
J=I/A;
disp(J,"current density J(in A/m^2)=");
```

Scilab code Exa 6.4 The mobile charge density

```
clc;
clear;
format('e',11)
D=10.5*10^3;                    //density of
   silver.
m=107.9*10^-3;                  //atomic mass
   of silver.
e=-1.602*10^-19;                //charge of
   electron.
Na=6.022*10^23;                 //Avogadro's
   no.
N1=Na/m;                        //N1=no. of
   atoms per kg.
N2=N1*D;                        //N2=no. of
   atoms per cube meter.
rho_m=N2*e;                     //rho_m=mobile
    charge density.
disp(rho_m,"mobile charge density(in C/m^3)=")
```

Scilab code Exa 6.5 Velocity of the mobile charge

```
clc;
clear;
format('e',11)
rho_m=-9.39*10^9;
J=1.2732*10^6;
v=abs(J/rho_m);
disp(v,"magnitude of the velosity of the mobile
   charge carriers(in m/s)=");
```

Scilab code Exa 6.8 Current density in conductor

```

clc;
clear;
format('v',11)
E=1;
d=1*10^-3;
A=(%pi*d^2)/4;          //A=area of the cross-section.
sigma=58.14*10^6;    //conductivity of copper.
J=sigma*E;
disp(J,"The current density in copper(in A/m^2)=");
I=J*A;
disp(I,"The current in the wire I(in ampere)=");
```

Scilab code Exa 6.10 Relaxation time for conductors

```
clc;
```

```
clear;
format('e',11);
rho_v_tf=10^-18;
rho_v_t0=1;
tf=log(rho_v_tf)/(-6.6*10^18);                    //from
    rho_v_tf=rho_v_t0*exp(-sigma/epsilone0*t) and for
     copper,taking sigma/epsilone0=6.6*10^18.
disp(tf,"The time taken by the charge to dissipate(
    in sec)=");
```

Scilab code Exa 6.11 The drift velocity and mobility of electrons

```

clc;
clear;
format('e',11);
I=1;
d=1*10^-3;
A=(3.14*d^2)/4;                    //cross section area
    .
rho_m=9.39*10^9;                   //mobile charge
    density for silver.(calculated in example 6.4).
sigma=6.25*10^7;                   //conductivity of
    silver.
J=I/A;
vd=J/rho_m;
disp(vd,"The drift velocity(in m/s)=");
E=J/sigma;
disp(E,"The electric field(in V/m)=");
M=vd/E;                            //M=mobility of
    electron.
disp(M,"The mobility of electron(in m^2/V.s)= ");
T=300;
me=9.109*10^-31;                   //mass of electron.
K=1.38*10^-23;
```

```
vth=sqrt(2*K*T/me);                    //estimating velocity of an electron whose kinetic energy is exactly 1KT for T=300k.
disp(vth,"The thermal velocity(in m/s)=");
r=vth/vd;                              //comparing drift velocity with the velocity attained due to thermal motion.
disp("times the drift velocity.",r,"The velocity attained due to thermal motion is ");
```

Scilab code Exa 6.15 The conductivity of the material

```
clc;
clear;
format('v',11);
disp("The impurity is type 3 so the dopped material is a P-type semiconductor adn hence nh=3*10^23");
nh=3*10^23;
Mh=0.05;                               //Mh=mobility of holes
sigma=nh*Mh*1.6*10^-19;                //as nh>>ne, because of impurity.
disp(sigma,"The conductivity of the material(in mho/m)=");
```

Scilab code Exa 6.16 The polarisation density in die electric

```
clc;
clear;
format('e',11);
E=1;
epsilone_r=1.5;
```

```
Xe=epsilone_r-1;                    //Xe=electric susceptibility.
epsilone_0=8.85*10^-12;
P=epsilone_0*Xe*E;
disp(P,"The polarisation density(in C/m^2)=");
```

Scilab code Exa 6.19 Boundry condition for electrostatic field

```
clc;
clear;
format('e',11);
epsilone_0=8.85*10^-12;
epsilone_r1=2;
epsilone_r2=4;
E1=[-3 5 7];
E1_tan=[-3 5 0];             //tangential component of E1.
E1_n=[0 0 7];                //normal component of E1.
E2_tan=E1_tan;               //as the tangential electric field is continous.
D2_tan=epsilone_r2*epsilone_0*E2_tan;
D1_n=epsilone_r1*epsilone_0*E1_n;
D2_n=D1_n;                  //as the normal electric flux density is continous.
D2=D2_tan+D2_n;
E2=D2/(4*epsilone_0);
disp(D2,"D2=");
disp(E2,"E2=");
Xe1=epsilone_r1-1;           //Xe1=electric susceptibility of the region1.
Xe2=epsilone_r2-1;           //Xe2=electric susceptibility of region2.
P2=epsilone_0*Xe2*E2;
disp(P2,"P2=");
```

Chapter 7

Laplace and Poisson Equations

Scilab code Exa 7.7 The voltage in coaxial cylinders

```
clc;
clear;
format('v',6);
V1=60;
V2=20;
r1=2;              //in cm
r2=6;              //in cm
r=4;               //in cm
disp("where A and B are constants.","V=A*ln(r)+B","
   The potential  V as a function of coordinates is
   ");
disp("B=85.2","A=-36.4","using the given data,we get
   ");
V=-36.4*log(r)+85.2;
disp(V,"The potential at r=4 cm,V(in volt)=");
```

Chapter 9

Magnetic forces Inductance and Magnetisation

Scilab code Exa 9.2 electron moving in a steady magnetic field

```
clc;
clear;
format('e',11);
v=4*10^4;
e=-1.6*10^-19;
Me=9.1*10^-31;                  //Me=mass of electron.
B=0.4*10^-4;
Wc=-e*B/Me;                     //Wc=angular frequency.
f=Wc/(2*3.14);
R=v/Wc;
disp(f,"The frequency of the electron(in Hz)=");
disp(R,"The redius of the circle,R(in meter)=");
```

Scilab code Exa 9.4 Force on the moving charge in steady magnetic field

```
clc;
```

```
clear;
format('e',11);
q=1*10^-9;
H=[1 0 0];
B=H*(4*3.14*10^-7);

//case-a

v=[0 0 0];
u1=v(1,2)*B(1,3)-v(1,3)*B(1,2);
u2=v(1,3)*B(1,1)-v(1,1)*B(1,3);
u3=v(1,1)*B(1,2)-v(1,2)*B(1,1);
R=[u1,u2,u3];                        //cross product of v and B.
F=q*R;
disp(F,"The force on the charge(in newton)=");

//case-b

v=[2 3 0];
u1=v(1,2)*B(1,3)-v(1,3)*B(1,2);
u2=v(1,3)*B(1,1)-v(1,1)*B(1,3);
u3=v(1,1)*B(1,2)-v(1,2)*B(1,1);
R=[u1,u2,u3];                        //cross product of v and B.
F=q*R;
disp(F,"The force on the charge(in newton)=");
```

Scilab code Exa 9.6 force on a straight wire carrying current in a magnetic field

```
clc;
clear;
format('v',6);
Ai=[0 0 0];                  //initial point.
```

```
Bf=[1 2 3];                        //final point.
B=[4 5 6];
I=10;
l=Bf-Ai;                       //l=length of the wire.
u1=l(1,2)*B(1,3)-l(1,3)*B(1,2);
u2=l(1,3)*B(1,1)-l(1,1)*B(1,3);
u3=l(1,1)*B(1,2)-l(1,2)*B(1,1);
R=[u1,u2,u3];                           //cross product
   of l and B.
F=I*R;
mag_F=sqrt(F(1)^2+F(2)^2+F(3)^2);
disp(F,"The force on the wire,F(in newton)=");
disp(mag_F,"The magnitude of the force(in newton)=")
   ;
```

Scilab code Exa 9.7 force between two current carring parallel conductor

```
clc;
clear;
format('v',6);
rho=0.01;                             //rho=sepration
   between two wires.
I=100;
H=[-I/(2*3.14*rho) 0 0]           //H=The magnetic
   field produced by the wire along the Z axis,by
   placing the z-axis(current flowing along the
   positive z-axis) along one of the wires,and the
   other wire at y=0.01m.
B=4*3.14*10^-7*H;
dir1=[0 0 -1]                         //direction of the
   velocity of the electrons.
u1=dir1(1,2)*B(1,3)-dir1(1,3)*B(1,2);
u2=dir1(1,3)*B(1,1)-dir1(1,1)*B(1,3);
u3=dir1(1,1)*B(1,2)-dir1(1,2)*B(1,1);
R=[u1,u2,u3];                           //cross product
```

```
of l and B.
F=I*R;                                        //F=force per unit lenth on the other wire placed in the magnetic field of former wire.
F5m=5*F;                                      //F5m=force on 5 m of the wire.
disp(F5m,"the force on the 5m of the wire,F5m(in newton)=");
```

Scilab code Exa 9.13 inductance of a coil

```
clc;
clear;
format('e',11);
d=0.01;
l=0.0254;
N=20;
A=3.14*(d^2)/4;                               //A=cross section area.
L=4*3.14*10^-7*N^2*A/l;
disp(L,"The inductance of the coil by the first method, L(in H)=");
L=A*4*3.14*10^-7*N^2/(2*sqrt((l/2)^2+A/3.14));
disp(L,"The inductance of the coil by the second method, L(in H)=");
```

Scilab code Exa 9.14 Wheeler formula

```
clc;
clear;
format('e',11);
d=0.01/0.0254;                                //in inches.
r=d/2;
```

```
l=1;                                    //in inches.
N=20;
L=(r^2)*(N^2)/(9*r+10*l);              //Wheeler's
    formula.
disp(L,"The inductance of the coil by Wheelers
    formula,L(in micro H)=");
```

Scilab code Exa 9.17 Inductance per meter of a coaxial line

```
clc;
clear;
format('e',11);
a=0.001;
b=0.0047;
L=4*3.14*10^-7*log(b/a)/(2*3.14);
disp(L,"The inductance per meter of the coaxial line
    ,L(in H)=");
```

Scilab code Exa 9.19 Inductance of single loop of wire

```
clc;
clear;
format('e',11);
R=0.005;
a=0.001;
L=4*3.14*10^-7*R*(log(8*R/a)-3/2);
disp(L,"The inductance of the loop,L(in H)=");
```

Chapter 10

Time dependent fields

Scilab code Exa 10.15 the diraction of travelling wave and its velocity

```
clc;
clear;
format('e',11);
disp("The wave is travelling in the positive x direction due to the negative sign in the argument of the given wave function.");
w=2*%pi*10^7;                          //by inspection of the given wave function.
k=100*2*%pi;                           //by inspection of the given wave function.
v=w/k;
disp(v,"The velocity of the wave,v(in m/s)=");
```

Chapter 11

Electromagnetic Waves

Scilab code Exa 11.1 the propagation constant

```
clc;
clear;
format('e',11);
w=2*%pi*10^9;
c=3*10^8;                //c=velocity of wave in air.
k=w/c;
disp(k,"The propagation constant,k(in rad/m)=");
```

Scilab code Exa 11.4 Uniform Plane Wave

```
clc;
clear;
format('v',11);
w=2*%pi*10^7;                    //from inspection of
    the given E field.
f=w/(2*%pi);
c=3*10^8;                        //c=velocity of the
   wave in air.
```

```
lemda=c/f;
k=2*%pi/lemda;
disp(lemda,"The wavelength(in meter)=");
disp(k,"The propagation constant,k(in rad/m)=");
```

Scilab code Exa 11.5 magnitude of the electric and magnetic field vectors

```
clc;
clear;
format('v',11);
S=10^6;
Z0=377;
E=sqrt(S*Z0);
H=E/Z0;
disp(E,"The magnitude of the electric field vector,E
   (in V/m)=");
disp(H,"The magnitude of the magnetic field vector,H
   (in A/m)=");
```

Scilab code Exa 11.10 the complex propagation constant

```
clc;
clear;
format('v',11);
f=1*10^6;
w=2*%pi*f;
sigma=2*10^-5;
epsilone_r=15;
epsilone_0=8.85*10^-12;
epsilone=epsilone_0*epsilone_r;
epsilone_c=epsilone*(1-%i*(sigma/(w*epsilone)));
Bc=w*sqrt(4*%pi*10^-7*epsilone_c);
disp(Bc,"Bc=");
```

Scilab code Exa 11.11 low conductivity materials

```
clc;
clear;
format('e',11);
f=10*10^9;
epsilone_r=2;
epsilone_0=8.85*10^-12;
epsilone=epsilone_r*epsilone_0;
loss_tangent=0.05;
epsilone_c=epsilone*(1-%i*loss_tangent);
w=2*%pi*f;
B_0=w*sqrt((4*%pi*10^-7)*epsilone);
B=B_0*(1+(loss_tangent^2)/8);
alpha=B_0/2*loss_tangent;
delta=1/alpha;              //skin depth.4
Z=sqrt((4*%pi*10^-7)/epsilone_c);
disp(B_0,"B_0=");
disp(B,"B=");
disp(alpha,"alpha=");
disp(delta,"skin depth(in meter)=");
disp(Z,"Characteristic impedence,Z(in Ohm)=");
```

Scilab code Exa 11.12 propagation constant skin depth and the wave length in high conductivity materials

```
clc;
clear;
format('v',11);
f=1*10^6;
w=2*%pi*f;
```

```
sigma=5.814*10^7;
epsilone_0=8.85*10^-12;
epsilone=epsilone_0;
loss_tangent=sigma/(w*epsilone);
disp(loss_tangent,"loss tangent=");
beta1=sqrt((w*sigma*4*%pi*10^-7)/2);                    // as loss tangent>>1.
alpha=beta1;                                             // as loss tangent>>1.
delta=1/alpha;
lemda_copper=2*%pi/beta1;
disp(beta1,"beta=");
disp(alpha,"alpha=");
disp(delta,"skin depth(in meter)=");
disp(lemda_copper,"The wave length(in meter)=");
```

Scilab code Exa 11.15 maxima minima and zeros of the standing wave

```
clc;
clear;
format('v',11);
f=1*10^9;
c=3*10^8;                  //velocity of light in air.
lemda=c/f;
T=1/f;
disp("E=-2*sin(2*%pi*z/0.3)","At t=T/4,equation of electric field is ");
Zmax1=(%pi/2)*0.3/(2*%pi);
Zmax2=(5*%pi/2)*0.3/(2*%pi);
Zmax3=(9*%pi/2)*0.3/(2*%pi);
Zmin1=(3*%pi/2)*0.3/(2*%pi);
Zmin2=(7*%pi/2)*0.3/(2*%pi);
Zmin3=(11*%pi/2)*0.3/(2*%pi);
Zzero1=(0*%pi)*0.3/(2*%pi);
Zzero2=(1*%pi)*0.3/(2*%pi);
```

```
Zzero3=(2*%pi)*0.3/(2*%pi);
disp(Zmax3,"Zmax3(in meter)=",Zmax2,"Zmax2(in meter)
    =",Zmax1,"Zmax1(in meter)=");
disp(Zmin3,"Zmin3(in meter)=",Zmin2,"Zmin2(in meter)
    =",Zmin1,"Zmin1(in meter)=");
disp(Zzero3,"Zzero3(in meter)=",Zzero2,"Zzero2(in
    meter)=",Zzero1,"Zzero1(in meter)=");
```

Scilab code Exa 11.18 The Brewster angle

```
clc;
clear;
format('v',11);
epsilone_r=80;
theta_b=atand(sqrt(epsilone_r));
disp(theta_b,"the Brewster angle(in degree)=");
```

Chapter 12

Transmission Lines and Waveguides

Scilab code Exa 12.2 attenuation factor and characteristic impedence

```
clc;
clear;
format('v',11);
R=42.9*10^-3;
L=0.7*10^-6;
C=0.1*10^-9;
G=24*10^-9;
w=5000;
gama=sqrt((R+%i*w*L)*(G+%i*w*C));
alpha=real(gama);
beta=imag(gama);
disp(alpha,"alpha(in Neper/m)=",beta,"beta(in rad/m)
   =");
vp=w/beta;
disp(vp,"The phase velocity(in m/s)=");
Z0=sqrt((R+%i*w*L)/(G+%i*w*C));
disp(Z0,"The characteristic impedance(in Ohm)=");
```

Scilab code Exa 12.3 L and C for the physical tansmission lines

```
clc;
clear;
format('v',11);
Z=75;
epsilone_r=2.56;
epsilone_0=8.85*10^-12;
m_0=4*%pi*10^-7;                    //The permeability
    of air.
a=1*10^-3;
b=a*exp(Z*2*%pi*sqrt(epsilone_0*epsilone_r/m_0));
disp(b,"b(in meter)=");
C=(2*%pi*epsilone_0*epsilone_r)/log(b/a);
disp(C,"The capacitance(in F/m)=");
L=(m_0/(2*%pi))*log(b/a);
disp(L,"The inductance(in H/m)=");
```

Scilab code Exa 12.4 distance between the conductors for two wire line

```
clc;
clear;
format('v',11);
epsilone_0=8.85*10^-12;
m_0=4*%pi*10^-7;                    //The permeability
    of air.
Z=300;
a=1*10^-3;
b=2*a*cosh(Z*%pi*sqrt(epsilone_0/m_0));
disp(b,"b(in meter)=");
```

Scilab code Exa 12.20 modes that propagate in parallel plate waveguide

```
clc;
clear;
format('e',11);
f=15*10^9;
w=2*%pi*f;
a=0.03;
epsilone_0=8.85*10^-12;
m_0=4*%pi*10^-7;                    //The permeability of air.
//for TEM mode.
k=w*sqrt(m_0*epsilone_0);
beta=k;
disp(beta);
Z0=sqrt(m_0/epsilone_0);
lemda_g=2*%pi/beta;
disp(Z0,"The wave impedence(in Ohm)=");
disp(lemda_g,"The wavelength(in meter)=");
//for TE modes.
lemda_c10=2*0.03/1;                     //for m=1.
lemda_c20=2*0.03/2;                     //for m=2.
lemda_c30=2*0.03/3;                     //for m=3.
lemda=3*10^8/f;                         //free space wavelength.
disp(lemda_c30,"lemda_c30(in meter)=",lemda_c20,"lemda_c20(in meter)=",lemda_c10,"lemda_c10(in meter)=");
disp(lemda,"Free space wavelength(in meter)=");
disp("so,only first two modes will propagate.","lemda must be less then lemda_cm,");
beta_10=sqrt(k^2-(%pi/a)^2);
beta_20=sqrt(k^2-(2*%pi/a)^2);
lemda_g10=2*%pi/beta_10;
```

```
lemda_g20=2*%pi/beta_20;
disp(beta_20,"beta_20(in rad/m)=",beta_10,"beta_10(
    in rad/m)=");
disp(lemda_g20,"lemda_g20(in meter)=",lemda_g10,"
    lemda_g10(in meter)=");
vp_10=w/beta_10;              //phase velocity.
vp_20=w/beta_20;
disp(vp_20,"vp_20(in m/s)=",vp_10,"vp_10(in m/s)=");
```

Scilab code Exa 12.23 the resonent frequency for the TM modes

```
clc;
clear;
format('v',11);
a=0.05;
b=0.04;
c=0.03;
m=1;
n=1;
v=3*10^8;
//for p=0.
p=0;
fr110=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr110,"fr110(in Hz)=");
//for p=1.
p=1;
fr111=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr111,"fr111(in Hz)=");
```

Scilab code Exa 12.24 the resonant frequency for the TE modes

```
clc;
clear;
```

```
format('e',11);
a=0.05;
b=0.04;
c=0.03;
v=3*10^8;
p=1;
//for m=0,n=1.

m=0;
n=1;
fr011=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr011,"fr011(in Hz)=");

//for m=1,n=0.
m=1;
n=0;
fr101=v/2*sqrt((m/a)^2+(n/b)^2+(p/c)^2);
disp(fr101,"fr101(in Hz)=");
```

Chapter 13

Radiation from Currents

Scilab code Exa 13.11 The power density radiated

```
clc;
clear;
format('v',6);
Pt=10^6;
Ddb=23;
r=10^4;
Pisotropic=Pt/(4*%pi*r^2);
D=10^(Ddb/10);
P_main_beam=D*Pisotropic;
disp(P_main_beam,"The power density radiated in the
    diection of main beam(in W/m^2)=");
```

Scilab code Exa 13.14 The power received by the receiving antenna

```
clc;
clear all;
format('v',6);
Dt=1.64;
```

```
Dr=1.64;
Pt=1;
c=3*10^8;
f=100*10^6;
r=1*10^3;
lemda_air=c/f;
Aer=lemda_air*Dr/(4*%pi);
P=Pt*Dt/(4*%pi*r^2);
Pr=P*Aer;
Pr=Pr*10^9;.....//in nW
disp(Pr,"The received power(in nW)=");
```

Scilab code Exa 13.15 The transmitted power

```
clc;
clear;
format('e',11);
f=10*10^9;
Pr=1*10^-6;
D=10;
r=5*10^3;
sigma=10;
c=3*10^8;
lemda=c/f;
Ae=lemda^2*D/(4*%pi);
Pt=Pr*(4*%pi*5000)^2/(D*sigma*Ae);
disp(Pt,"The transmitted power(in watt)=");
```

Chapter 14

Introduction to Antennas

Scilab code Exa 14.4 the first sidelobe level

```
clc;
clear;
format('v',11);
N=4;
disp("E=|sin(2*theta)/(N*sin(theta/2))|","The array
   factor is given as");
Eslmax=abs(1/(4*sin(3*%pi/4)));
   //for the first sidelobe,the sidelobe maximum is
   at 2*theta=3*%pi/2.
Edb=20*log10(Eslmax);
disp(Eslmax,"The sidelobe level=");
disp(Edb,"The sidelobe level(in db)=");
```

Scilab code Exa 14.5 The progressive phase shift and BWFN

```
clc;
clear;
format('v',11);
```

```
N=10;
phi_0=45;
kd=%pi;
alpha=-1*180*cosd(phi_0);
disp(alpha,"The progressive phase shift(in degree)="
    );
disp("sin(phi_0)*del_phi_fn+cos(phi_0)*del_phi_fn
    ^2/2=2*%pi/(N*kd)0","to find the BWFN, solving the
     equation");
del_phi_fn=14.4;
BWFN=2*del_phi_fn;
disp(BWFN,"The BWFN(in degree)=");
```

Scilab code Exa 14.6 Design of uniform antenna array

```
clc;
clear;
format('v',11);
BWFN=10;
del_phi_fn=BWFN/2*%pi/180;                        //in
     radian.
phi_0=45;
kd=%pi;
N=2*%pi/(kd*(sind(phi_0)*del_phi_fn+cosd(phi_0)*
    del_phi_fn^2/2));
disp(N,"no of elements=");
```

Scilab code Exa 14.10 The flare angle

```
clc;
clear;
format('v',6);
L=5;
```

```
delta_0=0.25;
theta=2*acosd(L/(L+delta_0));
disp(theta,"the E plane flare angle(in degree)=");
```

Scilab code Exa 14.12 The directivity and half power beam width

```
clc;
clear;
format('v',6);
aE=5;
aH=10;
Ap=aE*aH;
epsilone_ap=0.6;                        //assuming.
Ae=epsilone_ap*Ap;
D=4*%pi*Ae;
disp(D,"The directivity=");
HPBW_E=56/aE;
HPBW_H=67/aH;
disp(HPBW_E,"the E plane HPBW(in degree)=");
disp(HPBW_H,"the H plane HPBW(in degree)=");
```

Scilab code Exa 14.14 The directivity of the horn

```
clc;
clear;
format('v',11);
Ap=%pi*(3/2)^2;
Ae=0.6*Ap;
D=4*%pi*Ae;
disp(D,"The directivity=");
```

Chapter 15

Radio Wave Propagation

Scilab code Exa 15.6 the distance for surface wave which can be used for given frequency

```
clc;
clear;
format('v',6);
f=10;
d=1.6*50/f^(1/3);
disp(d,"d(in km)=");
```

Scilab code Exa 15.7 the refractive index of the atmosphere

```
clc;
clear;
format('v',11);
h=1000;
T=300;
p=1000*exp(-h/8000);
N=77.6*p/T;
n=1+N*10^-6;
disp(n,"n=");
```

Scilab code Exa 15.11 The plasma frequency

```
clc;
clear;
format('e',11);
N=3*10^10;
me=9.109*10^-31;
e=1.6*10^-19;
epsilone_0=8.85*10^-12;
Wp=sqrt(N*e^2/(me*epsilone_0));
disp(Wp,"the plasma frequency(in rad/s)");
```

Scilab code Exa 15.12 the electron density at which the wave is reflected back

```
clc;
clear;
format('e',11);
phi=45;
f=10*10^6;
Ntb=(f*cosd(phi))^2/81*10^-6;
disp(Ntb,"The electron density(in electrons/cc)=");
```

Scilab code Exa 15.13 the critical frequency

```
clc;
clear;
format('e',11);
Nmax=2*10^12;
```

```
fcr=9*sqrt(Nmax);
disp(fcr,"the critical frequency(in Hz)=");
```

Scilab code Exa 15.14 the electron density and height of the layer

```
clc;
clear;
format('e',11);
f=5*10^6;
t=10^-3;
c=3*10^8;
d=c*t;
h=d/2;                    //assuming that the virtual
    and atual heights are almost same.
disp(h,"height of the layer(in meter)=");
N=f^2/81*10^-6;                  //as phi=0.
disp(N,"N(in electronc/cc)=");
```