Scilab Textbook Companion for Elements of Electromagnetics by M. N. O. Sadiku[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

Vector Algebra

Scilab code Exa 1.1 Component and Magnitude of Vector

```
clear;
clc;
format('v',6)
A=[10,-4,6];
B=[2,1,0];
disp(A(1,2),'Component of A along ay : ')
P=3*A-B;
disp((P(1,1)^2+P(1,2)^2+P(1,3)^2)^0.5,'magnitude is
    :')
C=A+2*B;
det_C=(C(1,1)^2+C(1,2)^2+C(1,3)^2)^0.5;
format('v',7)
ac=C/det_C;
disp(ac,'Unit Vector along C is :')
```

Scilab code Exa 1.2 Distance between points

```
clear;
```

```
clc;
format('v',6);
P=[0,2,4];
Q=[-3,1,5];
origin=[0,0,0];
rp=P-origin;
disp(rp,'Position Vector of P is :')
rpq=Q-P;
disp(rpq,'Position Vector from P to Q is :')
det_rpq=(rpq(1,1)^2+rpq(1,2)^2+rpq(1,3)^2)^0.5;
disp(det_rpq,'distance between P and Q is :')
A=10*rpq/det_rpq;
disp([A;-A],'Vectors parallel to PQ with magnitude
    of 10 :')
```

Scilab code Exa 1.3 Relative Velocity

```
format ('v',6);
vb= [10*cos(%pi/4), -10*sin(%pi/4)]
vm= [-2*cos(%pi/4), -2*sin(%pi/4)]
vmg= vb+vm;
disp (vmg, 'Velocity of man with respect to ground:'
    )
mod_vmg=(vmg(1,1)^2+vmg(1,2)^2)^.5;
dir= atand(vmg(1,2)/vmg(1,1))
disp( mod_vmg,'Absolute velocity of man is:' )
disp (dir,'Angle with east in radian:')
```

Scilab code Exa 1.4 Angle between vectors

```
clear;
clc;
A=[3,4,1];
```

```
B=[0,2,-5];
det_A=(A(1,1)^2+A(1,2)^2+A(1,3)^2)^0.5;
det_B=(B(1,1)^2+B(1,2)^2+B(1,3)^2)^0.5;
theta=acosd((sum(A.*B))/(det_A*det_B));
disp(theta,'Angle between A and B is :')
```

Scilab code Exa 1.5 Cross Product

```
clear;
clc;
format('v',7);
P=[2,0,-1];
Q=[2,-1,2];
R=[2,-3,1];
S=P+Q;
T=P-Q;
U1=S(1,2)*T(1,3)-S(1,3)*T(1,2);
U2=S(1,3)*T(1,1)-S(1,1)*T(1,3);
U3=S(1,1)*T(1,2)-S(1,2)*T(1,1);
U=[U1 U2 U3];
disp(U,'(P+Q)*(P-Q)=')
V1=R(1,2)*P(1,3)-R(1,3)*P(1,2);
V2=R(1,3)*P(1,1)-R(1,1)*P(1,3);
V3=R(1,1)*P(1,2)-R(1,2)*P(1,1);
V=[V1 V2 V3];
X=(Q(1,1)*V(1,1)+Q(1,2)*V(1,2)+Q(1,3)*V(1,3));
disp(X,'Q.R*P')
W1=Q(1,2)*R(1,3)-Q(1,3)*R(1,2);
W2=Q(1,3)*R(1,1)-Q(1,1)*R(1,3);
W3=Q(1,1)*R(1,2)-Q(1,2)*R(1,1);
W=[W1 W2 W3];
Y=(W(1,1)*P(1,1)+W(1,2)*P(1,2)+W(1,3)*P(1,3));
disp(Y,'P.Q*R')
det_W=(W(1,1)^2+W(1,2)^2+W(1,3)^2)^.5;
det_Q=(Q(1,1)^2+Q(1,2)^2+Q(1,3)^2)^.5;
```

```
det_R=(R(1,1)^2+R(1,2)^2+R(1,3)^2)^.5
sineoftheta=(det_W/(det_Q*det_R));
disp(sineoftheta,'sin of theta=')
Z1=P(1,2)*W(1,3)-P(1,3)*W(1,2);
Z2=P(1,3)*W(1,1)-P(1,1)*W(1,3);
Z3=P(1,1)*W(1,2)-P(1,2)*W(1,1);
Z=[Z1 Z2 Z3];
disp(Z,'P* Q*R=')
disp(W/det_W,'Unit Vector Perpendicular to Q & R')
q=Q/det_Q;
C=(P(1,1)*q(1,1)+P(1,2)*q(1,2)+P(1,3)*q(1,3));
disp(C*q,'Component of P along Q');
```

Scilab code Exa 1.7 Cross Product

```
clear;
clc;
format('v',6);
P1=[5 2 -4];
P2=[1 1 2];
P3=[-3 0 8];
P4=[3 -1 0]
R1=P1-P2;
R2=P1-P3;
R3=P2-P3;
R4=P1-P4;
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);
U=[U1 U2 U3];
disp(U)
disp('Since U is Zero so P1,P2,P3 are in straight line')
det_R1=(R1(1,1)^2+R1(1,2)^2+R1(1,3)^2)^.5;
V1=R4(1,2)*R1(1,3)-R4(1,3)*R1(1,2);
```

```
V2=R4(1,3)*R1(1,1)-R4(1,1)*R1(1,3);
V3=R4(1,1)*R1(1,2)-R4(1,2)*R1(1,1);
V=[V1 V2 V3];
det_V=(V(1,1)^2+V(1,2)^2+V(1,3)^2)^.5;
det_R1=(R1(1,1)^2+R1(1,2)^2+R1(1,3)^2)^.5;
disp((det_V/det_R1),'Shortest Distance')
```

Chapter 2

Coordinate Systems And Transformation

Scilab code Exa 2.1 Change of coordinate system

```
clear;
clc;
format('v',7);
x=-2;y=6;z=3;
r=(x^2+y^2)^.5;
B=atand(y/x);
R=sqrt(x^2+y^2+z^2);
X=atand(r/z);
disp([r B z ],'Cylindrical acordinate of P:');
disp([R X B],'Spherical Cordinate of P:');
A=[cosd(B) sind(B) 0;-sind(B) cosd(B) 0;0 0 1]*[y;x+z;0];
disp (A,'A in cylindrical cordinates')
```

Scilab code Exa 2.2 Spherical to cylindrical and Cartesian

```
clear;
clc;
format('v',6);
function [X,Y,Z]=sptocart(x,y,z);
R=sqrt(x^2+y^2+z^2);r=sqrt(x^2+y^2);
P=asin(r/R);Q=acos(x/r);
X=(10/R)*sin(P)*cos(Q)+R*(cos(P))^2 *cos(Q)-sin(Q);
Y=(10/R)*sin(P)*sin(Q)+R*(cos(P))^2 *sin(Q)+cos(Q);
Z=(10/R)*cos(P)-R*cos(P)*sin(P);
disp([X Y Z],'B in cartesian cordinate')
endfunction
sptocart(-3,4,0);
function [r,p,z]=sptocylin(r1,p1,z1);
R=sqrt(r1^2+z1^2);
P=acos(z1/R);
r=(10/R)*sin(P)+R*(cos(P))^2 ;
p=1;
z=(10/R)*cos(P)-R*cos(P)*sin(P);
disp([r p z],'B in cylindrical cordinates');
endfunction
sptocylin(5,%pi/2,-2);
```

Scilab code Exa 2.3 Angle between vector and surfaces

```
clear;
clc;
E=[-5 10 3];ModE=sqrt((-5)^2+10^2+3^2);
F=[1 2 -6];
P=[5,%pi/2,3];
G1=E(1,2)*F(1,3)-E(1,3)*F(1,2);
G2=E(1,3)*F(1,1)-E(1,1)*F(1,3);
G3=E(1,1)*F(1,2)-E(1,2)*F(1,1);
G=[G1 G2 G3];
disp(sqrt(G1^2+G2^2+G3^2),'Mod of (E*F)');
ay=[sin(%pi/2) cos(%pi/2) 0];
```

```
Ey=(E(1,1)*ay(1,1)+E(1,2)*ay(1,2)+E(1,3)*ay(1,3));
disp(Ey,'Component of E parallel to x=2 & z=3');
P=acosd(3/ModE);
disp(90-P,'Angle which make E wid Z=3');
```

Scilab code Exa 2.4 Different Components of a Vector

```
clear;
clc;
format('v',6)
function [R,P,Q]=Posvec(r,p,q);
R=r*sind(q);P=-sind(p)*cosd(q)/r;Q=r*r;
D=[R P Q];
disp(D,'D at P');
Dn=[r*sind(q) 0 0];
Dt=D-Dn;
disp(Dt, 'Tangential component of D at P');
endfunction
Posvec(10,150,330);
D=[-5 .043 100];
a=[0 1 0];
U1=D(1,2)*a(1,3)-D(1,3)*a(1,2);
U2=D(1,3)*a(1,1)-D(1,1)*a(1,3);
U3=D(1,1)*a(1,2)-D(1,2)*a(1,1);
U=[U1 U2 U3];
det_U=sqrt(U1^2+U2^2+U3^2);
format('v',7);
disp(U/det_U,'Unit vector P perpendicular to D');
```

Chapter 3

Vector Calculus

Scilab code Exa 3.1 Distace between points

```
clear;
clc;
B1=[0,5,0],B2=[5,%pi/2,0],C1=[0 5 10],C2=[5 %pi/2 0],D1=[5 0 10],D2=[5,0,10],p=5;
BC=integrate('1','Z',0,10);
disp(BC);   //as dl will be along dz
CD=integrate('5','Q',0,%pi/2);
disp(CD);   //dl will be along d(phi)
```

Scilab code Exa 3.2 Circulation of a vector

```
clear;
clc;
C1=integrate('x^2','x',1,0);//for y=0=z
C2=0;// as (az.ay)=0
C3=integrate('x^2 -1','x',0,1);
C4=integrate('-y-y^2','y',1,0);
C=C1+C2+C3+C4;
disp(C);
```

Scilab code Exa 3.9 Stroke Theorem

```
clear;
clc;
ab=integrate('2*sin(P)','P',%pi/3,%pi/6);
bc=(3^.5 /2)*integrate('p','p',2,5);
Cd=integrate('5*sin(P)','P',%pi/6,%pi/3);
da=.5*integrate('p','p',5,2);
C1=ab+bc+Cd+da;
disp(C1, 'C1=');
C2=integrate('sin(Q)','Q',%pi/6,%pi/3)*integrate('
   (1+p)','p',2,5);
disp(C2,'C2=');
disp('Since C1=C2 hence stroke theorem is proved');
```

Chapter 4

Electrostatics

Scilab code Exa 4.1 Coulomb Law

```
clear;
clc;
format('v',6);
Q1=1;
Q2=-2;
Q=10*10^-9;
P1=[0 3 1]-[3 2 -1];
P2=[0 3 1]-[-1 -1 4];

e=10^-9/(36*%pi);
det1=(P1(1,1)^2+P1(1,2)^2+P1(1,3)^2)^.5;
det2=(P2(1,1)^2+P2(1,2)^2+P2(1,3)^2)^.5;
F=[[(Q*Q1)*(P1)]/(4*%pi*e*(det1)^3)]+[[(Q*Q2)*(P2)
    ]/(4*%pi*e*(det2)^3)];
E=[(10^-6)*(F/Q)];
disp(F,'F(in mN)=');
disp(E,'At that point E(in kV)=');
```

Scilab code Exa 4.6 Electric Field

```
clear;
clc;
format('v',6);
p1=10*10^-9;
p2=15*10^-9;
pl=10*%pi*10^-9;
e=(10^-9)/(36*%pi);
E1=(p1/(2*e))*[-1 0 0];
E2=(p2/(2*e))*[0 1 0];
R=[1 0 -3];
p=(R(1,1)^2+R(1,2)^2+R(1,3)^2);
a=R/p;
E3=(pl/(2*%pi*e))*a;
E=E1+E2+E3;
disp(E,'E(in V) at (1,1,-1)=');
```

Scilab code Exa 4.7 Electric Flux

```
clear;
clc;
format('v',12);
e=10^-9;
Q=-5*%pi*10^-3;
pl=3*%pi*10^-3;
r=[4 0 3];
p=(r(1,1)^2+r(1,2)^2+r(1,3)^2)^.5;
r1=[4,0,0];
R=r-r1;
mod_R=(R(1,1)^2+R(1,2)^2+R(1,3)^2)^.5;
Dq=(Q*R)/(4*%pi*mod_R^3);
ap=r/p;
Dl=(pl/(2*%pi*p))*ap;
D=Dq+Dl;
disp(D*10^6,'Flux density D(in microC) due to a
    point charge and a infinite line charge');
```

Scilab code Exa 4.8 Guass Law

```
clear;
clc;
r1=0,r2=1,z1=-2,z2=2,q1=0,q2=2*%pi;
Q=integrate('p^2','p',r1,r2)*integrate('(cos(Q)^2)',
    'Q',q1,q2)*integrate('1','z',z1,z2);
disp(Q,'Total charge is =');
```

Scilab code Exa 4.10 Potential

```
clear;
clc;
format('v',6);
Q1=-4;
Q2=5;
R1=[1 0 1]-[2 -1 3];
R2=[1 0 1]-[0 4 -2];
e=10^-9/(36*%pi);
mod_R1=(R1(1,1)^2+R1(1,2)^2+R1(1,3)^2)^.5;
mod_R2=(R2(1,1)^2+R2(1,2)^2+R2(1,3)^2)^.5;
C0=0;
V=10^-6*(([Q1/mod_R1]+[Q2/mod_R2])/(4*%pi*e))+C0;
disp(V*10^-3,'V(1,0,1)(in kV)=');
```

Scilab code Exa 4.12 Relationship between E and V

```
clear;
clc;
```

```
q=10*10^-6;
function[V]=pot(r,P,Q);
V=10*sin(P)*cos(Q)/r^2;
endfunction
Va=pot(1,%pi/6,2*%pi/3);
Vb=pot(4,%pi/2,%pi/3);
W=q*(Vb-Va);
disp(W*10^6,'Work done in uJoule');
```

Scilab code Exa 4.13 Dipole

```
clear;
clc;
p1=-5*10^-9, p2=9*10^-9;
r1=2,r2=-3,e=10^-9/(36*%pi);
V=(1/(4*%pi*e))*((p1*abs(r1)/r1^3)+(p2*abs(r2)/r2^3)
    );
disp(V);
```

Scilab code Exa 4.14 Energy Density

```
clear;
clc;
format('v',6);
Q1=-1*10^-9 ,Q2=4*10^-9,Q3=3*10^-9,e=10^-9/(36*%pi);
V1=(1/(4*%pi*e) * (Q2+Q3)),V2=(1/(4*%pi*e)*(Q1+Q3
    /(2^.5)) ),V3=(1/(4*%pi*e) * (Q1+Q2/(2^.5)));
W=.5*((V1*Q1)+(V2*Q2)+(V3*Q3));
disp(W*10^9,'Energy in nJ');
```

Chapter 5

Electric Fields in Material Space

Scilab code Exa 5.1 Current through conductors

```
clear;
clc;
r=.2;
disp('J=1/r3(2cosP ar + sinP a)')
I=(2/r)*integrate('sin(P)*cos(P)','P',0,%pi/2)*
    integrate('1','Q',0,2*%pi);
disp(I,'Current passing through Hemispherical shell'
    );
I=(2/r)*integrate('sin(P)*cos(P)','P',0,%pi,10^-10)*
    integrate('1','Q',0,2*%pi);
disp(I,' Current through spherical shell= ');
```

Scilab code Exa 5.2 Charge Transport

```
clear;
clc;
```

```
format('v',12);
ps=10^-7;
u=2;
w=0.1;
t=5;
I=ps*u*w;
Q=I*t*10^9;
disp(Q,'charge(in nC) collected in 5 sec=');
```

Scilab code Exa 5.3 Charge Transport

```
clear;
clc;
format('v',12);
n=10^29;
e=-1.6*10^-19;
pv=n*e;
disp(pv*10^-6,'(a) pv(in MC/m3)=');
sigma=5*10^7;
E=10^-2;
J=sigma*E;
disp(J*10^-3,'(b) J(in kA/m2)=');
S=(%pi*10^-6)/4;
I=J*S;
format('v',6);
disp(I,'(c) I(in A)=');
u=J/pv;
format('v',12);
disp(u,'(d) u(in m/s)=');
```

Scilab code Exa 5.4 Conductor

```
clear;
```

```
clc;
format('v',6);
l=4;
d=3;
r=0.5;
S=(d^2-(%pi*r^2))*10^-4;
sigma=5*10^6;
R=(l*10^6)/(sigma*S);
disp(R,'R(in microohm)=');
```

Scilab code Exa 5.6 Dielectric

```
clear;
clc;
format('v',6);
e0=10^-9/(36*%pi);
er=2.55;
E=10^4;
d=1.5*10^-3;
D=e0*er*E*10^9;
disp(D,'D(in nC/m^2)=');
xe=1.55;
P=xe*e0*E*10^9;
disp(P,'P(in nC/m^2)=');
ps=D;
disp(ps,'ps(in nC/m^2)=');
pps=P;
disp(pps,'pps(in nC/m^2)=');
V=E*d;
disp(V,'V(in V)=');
```

Scilab code Exa 5.7 Dielectric

```
clear;
clc;
format('v',6);
Q=2*10^-12;
e0=(10^-9)/(36*%pi);
er=5.7;
xr=er-1;
r=10^-1;
E=Q*10^12/(4*%pi*e0*er*r^2);
P=xr*e0*E;
pps=P*1;
disp(pps,'(a) pps(in pC/m^2)=');
Q1=-4*10^-12;
F=(Q*Q1)*10^12/(4*%pi*e0*er*r^2);
disp(F,'(b) F(in pN)(in the direction of ar)=');
```

Scilab code Exa 5.9 Boundary Conditions

```
clear;
clc;
format('v',6);
an=[0 0 1];
E1=[5 -2 3];
er1=4;
er2=3;
e=(10^-9)/(36*%pi);
e1n=E1*an';
E1n=[0 0 e1n];
E2n=[0 0 E1n*[0;0;1]];
E1t=E1-E1n;
E2t=E1t;
E2n=(er1*E1n)/er2;
E2=E2t+E2n;
disp(E2,'E2=');
theta1=atand(((E1t(1,1)^2+E1t(1,2)^2+E1t(1,3)^2)
```

```
    ^0.5)/e1n);
alpha1=90-theta1;
disp(alpha1,'Angle of E1 with interface=');
alpha2=90-atand(((E2t(1,1)^2+E2t(1,2)^2+E2t(1,3)^2)
    ^0.5)/((E2n(1,1)^2+E2n(1,2)^2+E2n(1,3)^2)^0.5));
disp(alpha2,'Angle of E2 with interface=');
wE1=0.5*er1*e*10^12*(E1(1,1)^2+E1(1,2)^2+E1(1,3)^2);
wE2=0.5*er2*e*10^12*(E2(1,1)^2+E2(1,2)^2+E2(1,3)^2);
disp(wE1,'Energy densities are wE1(in uJ)=');
disp(wE2,'                         wE2(in uJ)=');
We=wE2*integrate('1','x',2,4)*integrate('1','y',3,5)
    *integrate('1','z',-6,-4)*10^-3;
disp(We,'We(in mJ)=');
```

Scilab code Exa 5.10 Boundary Conditions

```
clear;
clc;
format('v',12);
disp(0,'Point(3,-2,2) is in conductor region hence E
    =D=');
ps=2;
Dn=ps;
D=[0 Dn 0];
e=(10^-9)/(36*%pi);
er=2;
E=D/(e*er);
disp(D,'D=');
disp(E,'E=');
```

Chapter 6

Electrostatic Boundary Value Problems

Scilab code Exa 6.12 Capacitance

```
clear;
clc;
Eo=10^-9 /(36*%pi),Er1=4,Er2=6,d=5*10^-3,S=30*10^-4;
C1=Eo*Er1*S*2/d;
C2=Eo*Er2*S*2/d;
C=C1*C2/(C1+C2);//Since they are in series
disp(C*10^12,'Capacitance of capacitor in figure a
    in pF =');
C1=Eo*Er1*S/(2*d);
C2=Eo*Er2*S/(2*d);
C=C1+C2;
disp(C*10^12,'Capacitance of capacitor in figure b
    in pF = ')
```

Chapter 7

Magnetostatics

Scilab code Exa 7.1 Biot Savart Law

```
clear;
clc;
a1=acos(0),a2=acos(2/29^.5),p=5,I=10;
H=I/(4*%pi*p)*(cos(a1)-cos(a2));
disp(H*1000,'H at (0,0,5) in mA ');
```

Scilab code Exa 7.2 Biot Savart Law

```
clear;
clc;
a1=acos(0),a2=acos(1),p=5,I=3;
Hz=I/(4*%pi*p)*(cos(a2)-cos(a1))*[.8 .6 0];
a2=acos(1),a1=acos(.6),p=4,I=3;
Hx=I/(4*%pi*p)*(cos(a2)-cos(a1))*[0 0 1];
H=Hx+Hz;
disp(H*1000,'H at (0,0,5) in mA ');
```

Scilab code Exa 7.5 MF due to infinite long sheet

```
clear;
clc;
i0=-10,i4=10;
H0=.5*i0*-1;// in the positive Y direction
H4=.5*i4*-1*-1;//in the positive Y direction
H=H0+H4;
disp(H, 'H at (1,1,1) =')
H0=.5*i0*-1;//in the positive Y direction
H4=.5*i4*-1;//in the negative Y direction
H=H0+H4;
disp(H,'H at (0,-3,10 =)');
```

Scilab code Exa 7.7 Magnetic vector potential

```
clear;
clc;
disp('Vector potential A=-p^2/4');
Q=%pi/2,p1=1,p2=2,z1=0,z2=5
Y=.5*integrate('p','p',p1,p2)*integrate('1','z',z1,
   z2);
disp(Y,'Total magnetic flux= ')
```

Chapter 8

Magnetic Forces Materials and Devices

Scilab code Exa 8.1 Forces

```
clear;
clc;
m=2,q=3,v=[4 0 3],E=[12 10 0],t=1;
disp(q*E/m,'Acceleration ofthe particle= ');
u=[22 15 3];
modofu=sqrt(22*22+15*15+3*3);
KE=.5*m*(modofu)^2;
disp(KE, 'Kinetic energy= ')
```

Scilab code Exa 8.8 Boundary Condition

```
clear;
clc;
format('v',6);
H1=[-2 6 4],Uo=4*%pi*10^-7,Ur=5;
U1=Uo*Ur;
```

```
M1=(Ur-1)*H1;
disp(M1,'M = ');
B1=U1*H1;
disp(B1*10^6,'B in uW/m^2');
```

Scilab code Exa 8.14 Magnetic Circuit

```
clear;
clc;
p=10*10^-2 ,a=1*10^-2 ,Ur=1000, Uo=4*%pi*10^-7,n
    =200,phi=.5*10^-3;
U=Uo*Ur;
I=phi*2*%pi*p/(Uo*Ur*n*%pi*a*a);
disp(I);
```

Scilab code Exa 8.15 Magnetic Circuit

```
clear;
clc;
Uo=4*%pi*10^-7,Ur=50,l1=30*10^-2,s=10*10^-4,l3
    =9*10^-2,la=1*10^-2,B=1.5,N=400;
R1=l1/(Uo*Ur*s);R2=R1;
R3=l3/(Uo*Ur*s);
Ra=la/(Uo*s);
R=R1*R2/(R1+R2);
Req=R3+Ra+R;
I=B*s*Req/N;
disp(I,'Required current= ');
```

Scilab code Exa 8.16 Magnetic Circuit

```
clear;
clc;
m=400,g=9.8,Ur=3000, Uo=4*%pi*10^-7,S=40*10^-4,la=1*10^-4,li=50*10^-2,I=1;
B=sqrt(m*g*Uo/S);
Ra=2*la/(Uo*S);
Ri=li/(Uo*Ur*S);
N=(Ra+Ri)/(Ra*Uo)*B*la;
disp(N,'No of turns= ');
```

Chapter 9

Waves and Applications

Scilab code Exa 9.5 Complex numbers

```
clear;
clc;
z3=%i,z4=3+4*%i,z5=-1+6*%i,z6=3+4*%i;
z1=(z3*z4/(z5*z6));
disp(z1,'z1 =');
z7=1+%i, z8=4-8*%i;
z2=(z7/z8)^.5;
disp(z2,'z2 = ')
```

Chapter 10

Electromagnetic wave propagation

Scilab code Exa 10.1 Wave eqution

```
clear;
clc;
format('v',6);
disp('Direction of wave propagation is -ax');
w=10^8,c=3*10^8;
B=w/c;
disp(B,'Value of beta=');
T=2*%pi/w;
disp(T/2*10^9,'Time taken to travel half of wave
    length in nS= ');
t=0
x=-2*%pi:%pi/16:2*%pi;
Ey=50*cos(10^8 *t +B*x);
subplot(2,2,1)
plot(x,Ey);
t=T/4;
Ey=50*cos(10^8 *t +B*x);
subplot(2,2,2)
plot(x,Ey);
```

```
t=T/2;
Ey=50*cos(10^8 *t +B*x);
subplot(2,2,3)
plot(x,Ey);
```

Scilab code Exa 10.2 Waves in dielectrics

```
clear;
clc;
Ho=10,n=200*%e^(%i*%pi/6),P=atan(3^.5),b=.5,e=10^-9/(36*%pi);
Eo=n*Ho;
disp('a=w*sqrt(u*e/2*(1+(c/(w*e)^2)^.5)-1)');
disp('b=w*sqrt(u*e/2*(1+(c/(w*e)^2)^.5)+1)');
a=b*((sqrt(((1+(tan(P))^2)^.5)-1))/(sqrt(((1+(tan(P))^2)^.5)+1)));
disp(a,'Value of alpha=');
disp(1/a,'Skin depth = ')
```

Scilab code Exa 10.3 Waves in dielectrics

```
clear;
clc;
B=1,n=60*%pi,Ur=1,Eo=10^-9 /(36*%pi),Uo=4*%pi*10^-7;
Er=Uo*Ur/(n^2 *Eo);
disp(Er,'Er =');
w=B/sqrt(Eo*Er*Uo*Ur);
disp(w*10^-6, 'w in Mrad/sec');
```

Scilab code Exa 10.4 Waves in dielectrics

```
clear;
clc;
c=3,w=10^8,Ur=20,Eo=10^-9 /(36*%pi),Er=1,Uo=4*%pi
    *10^-7;
a=sqrt(Uo*Ur*w*c/2);
disp(a,'alpha = beta =');//as c/w*E>>1
```

Scilab code Exa 10.6 Waves in dielectrics

```
clear;
clc;
a=2*10^-3,b=6*10^-3,t=10^-3,l=2,c=5.8*10^7;
Ri=l/(c*%pi*a*a);
Ro=l/(c*%pi*((b+t)^2-b^2));
Rdc=Ro+Ri;
disp(Rdc*10^3,'Resistance in mOhm');
```

Scilab code Exa 10.7 Power

```
clear;
clc;
a=0,b=.8,Eo=10^-9 /(36*%pi),Uo=4*%pi*10^-7,Ur=1,w=2*
    %pi*10^7;
Er=b^2/(Uo*Eo*w*w);
disp(Er);
n=sqrt(Uo/(Eo*Er));
disp(n);
```

Scilab code Exa 10.10 Reflection of plane wave

```
clear;
clc;
kx=0,ky=.866,kz=.5,Eo=10^-9 /(36*%pi),Uo=4*%pi
   *10^-7;
k=sqrt(kx*kx+ky*ky+kz*kz);
w=k/(sqrt(Uo*Eo));
disp(w*10^-6,'w im Mrad/sec');
l=2*%pi/k;
disp(l,'lamda = ')
```

Chapter 11

Transmission Lines

Scilab code Exa 11.1 Inductance

```
clear;
clc;
format('v',6);
R=0,G=0,a=0,Ro=70,B=3,f=100*10^6;
w=2*%pi*f;
C=B/(w*Ro);
disp(C*10^12,'Capacitance per meter of line in pF')
L=Ro*Ro*C;
disp(L*10^9,'Inductance per meter in nHz')
```

Scilab code Exa 11.2 Finding various parameters

```
clear;
clc;
Zo=60,a=20*10^-3,u=.6*3*10^8, f=100*10^6;
R=a*Zo,disp(R,'R=');
L=Zo/u,disp(L*10^9,'L in nH=');
G=a*a/R,disp(G*10^6,'G in micro S per meter =');
```

```
C=1/(u*Zo),disp(C*10^12,'C in pF =');
l=u/f;disp(l,'l=');
```

Scilab code Exa 11.3 Calculative

```
clear;
clc;
format('v',6);
w=10^6,B=1,a=8,Vg=10;
Zo=60+40*%i,Zg=40,Zl=20+50*%i;
a=(a/8.686);;//Since 1Np=8.686 dB
Y=a+B*%i;
Yl=2*Y;
h=tanh(Yl);
Zin=Zo*(Zl+Zo*tanh(Yl))/(Zo+Zl*tanh(Yl));
disp(Zin,'The input impdence =');
Io=Vg/(Zin+Zg);//at z=0
disp(Io*1000,'Sending end current in mA =');
Vo=Zin*Io;
Vop =(Vo+Zo*Io)/2;
Vom =(Vo-Zo*Io)/2;
Im= ((Vop * %e^-Y)/Zo)- ((Vom * %e^Y)/Zo);
disp(Im*1000, 'Current at middle line in mA= ');
```

Scilab code Exa 11.4 Impedance

```
clear;
clc;
format('v',6);
l=30,Zo=50,f=2*10^6,Zl=60+40*%i,u=.6*3*10^8;
w=2*%pi*f;
T=(Zl-Zo)/(Zl+Zo);
disp(T,'Reflection coefficient =');
```

```
s=(1+abs(T))/(1-abs(T));
disp(s,'Standing wave ratio =');
B=w/u;disp(B*l);
Zin=Zo*(Zl+Zo*tan(B*l)*%i)/(Zo+Zl*tan(B*l)*%i);
disp(Zin);
```

Scilab code Exa 11.5 Smith chart problem

```
clear;
clc;
format('v',6);
Zl=100+150*%i;
Zo=75;
zl=Zl/Zo;
T=(Zl-Zo)/(Zl+Zo);
disp(T,'T =');
s=(1+abs(T))/(1-abs(T));
disp(s,'s =')
format('v',5);
Yl=1/Zl;
disp(Yl*1000,'Load admittance in mS');
B=2*%pi,l=.4;
Zin=Zo*(Zl+Zo*tan(B*l)*%i)/(Zo+Zl*tan(B*l)*%i);
format('v',6);
disp(Zin,'Zin at .4 l from load')//for .4l
B=2*%pi,l=.6;
Zin=Zo*(Zl+Zo*tan(B*l)*%i)/(Zo+Zl*tan(B*l)*%i);
format('v',6);
disp(Zin,'Zin at .6 l from load')//for .6l
```

Scilab code Exa 11.6 Application of transmission lines

```
clear;
```

```
clc;
s=2, l1=11,l2=19,ma=24,mi=16,u=3*10^8,Zo=50;
l=(l2-l1)*2;
disp(l,'Lamda =');
f=u/l;
disp(f*10^-6,'Frequency im MHz =');
L=(24-19)/l;//Let us assume load is at 24cm
zl=1.4+.75*%i; //by smith chart
Zl=Zo*zl;
disp(Zl,'Zl =')
```

Scilab code Exa 11.7 Application of transmission lines

```
clear;
clc;
format('v',6);
Zo=100, Zl=40+30*%i;
Yo=1/Zo;
yl=Zo/Zl;
ys1=1.04*%i, ys2=-1.04*%i; //By smith chart
Ys1=Yo*ys1, Ys2=Yo*ys2;
disp([Ys1*1000 Ys2*1000],'Possible values of sub
    admittance in mS =');
la=.5 - (62-(-39))/720 ;disp(la, 'distance between
    load and antenna at A devided by Lamda');
lb= (62-39)/720;disp(lb, 'distance between load and
    antenna at B devided by Lamda');//With the help
    of figure
da=88/720, db= 272/720;
format('v',7);
disp(da,db,'Sub length devided by Lamda');
```

Scilab code Exa 11.8 Transient of transmission lines

```
clear;
clc;
Zg=100,Zo=50,Zl=200,u=3*10^8,l=100,Vg=12;
Tg=(Zg-Zo)/(Zg+Zo);
Tl=(Zl-Zo)/(Zl+Zo);
t1=l/u;
```

Scilab code Exa 11.10 Microstrip transmission line

```
clear;
clc;
format('v',6);
Er=3.8, c=3*10^8;
r=4.5;//ratio w/h
Eeff= ((Er+1)/2)+ ((Er-1)/(2*(1+12/r)^.5));
disp(Eeff, 'The effective relative permittivity = ')
    ;
Zo=(120*%pi)/((r+1.393+ (.667*log(r+1.444)))*((Eeff)
    ^.5));
disp(Zo, 'Character impedence of line');
f=10^10;
l=c/(f*sqrt(Eeff));
disp(l*1000, 'The wavelength of line at 10 GHz');
```

Scilab code Exa 11.11 Microstrip transmission line

```
clear;
clc;
h=1, w=.8, Er=6.6, P= atan(.0001), c= 5.8*10^7,f
    =10^10,mu=4*%pi*10^(-7),C=3*10^8;
r=w/h;
Ee=((Er+1)/2)+ ((Er-1)/(2*(1+12/r)^.5));
```

```
Zo=(120*%pi)/((r+1.393+ (.667*log(r+1.444)))*((Ee)
    ^.5));
Rs=((%pi*f*mu)/c)^.5;
ac=8.686*Rs/(w*10^-3*Zo);
disp(ac,'Conduction Attenuation Constant = ');
l=C/(f*(Ee)^.5);
disp(l);
ad=27.3*(Ee-1)*Er*tan(P)/((Er-1)*Ee*l);
disp(ad,'Dielectric Attenuation Constant =');
```

Chapter 12

Waveguides

Scilab code Exa 12.1 Transverse Modes

```
clear;
clc;
a=2.5*10^-2, b=1*10^-2,c=0, Ur=1,Er=4,C=3*10^8;
fc=0,m=0,n=0;
while(fc*10^-9<15.1)
fc=(C/(4*a))*sqrt(m^2 + (a*n/b)^2);
if ((fc*10^-9) < 15.1) then
n=n+1;
else disp(n-1,'Max value of n is =');  end
end
fc=0,m=0,n=0;
while(fc*10^-9<15.1)
fc=(C/(4*a))*sqrt(m^2 + (a*n/b)^2);
if ((fc*10^-9) < 15.1) then
m=m+1;
else disp(m-1,'Max value of m is =');  end
end
function[p]= modes(m,n);
p=(C/(4*a))*sqrt(m^2 + (a*n/b)^2);
if ((p*10^-9) < 15.1) then
disp([m n],'Transmission mode is possible'); else p
```

```
=0;end
endfunction
for i=1:1:5, for j=1:1:2,modes(i,j);end;
end
```

Scilab code Exa 12.3 Transverse Modes

```
clear;
clc;
format('v',7);
a=1.5*10^-2,b=.8*10^-2,c=0,Uo=4*%pi*10^-7,Ur=1,Eo
   =10^-9/(36*%pi),Er=4,C=3*10^8,w=%pi*10^11,m=1,n
   =3;
u=C/2;
f=w/(2*%pi);
fc=u*((m*m)/(a*a) + (n*n)/(b*b) )^.5/2;
disp(fc*10^-9,'Cutoff frequency = ');
B=w*sqrt(Uo*Ur*Eo*Er)*sqrt(1-(fc/f)^2);
disp(B,'Phase constant = ');
disp(%i*B,'Propagation constant = ');
n=377/sqrt(Er)*sqrt(1-(fc/f)^2);
disp(n,'Intrinsic wave impedence = ');
```

Scilab code Exa 12.4 Wave propagation in guide

```
clear;
clc;
a=8.636*10^-2,b=4.318*10^-2,f=4*10^9;
u=3*10^8;
fc=u/(2*a);
disp(fc*10^-9,'Cut off frquency = ');
if(f>fc) then disp('As f>fc so TE10 mode will
   propagate')
```

```
else disp('It will not propagate')
end
Up=u/sqrt(1-(fc/f)^2);
disp(Up*10^-6,'Phase velocity in Mm/sec = ');
Ug=u*u/Up;
disp(Ug*10^-6,'Group velocity in Mm/sec = ');
```

Scilab code Exa 12.5 Power Transmission

```
clear;
clc;
f=10*10^9,a=4*10^-2,b=2*10^-2,u=3*10^8,Pavg=2*10^-3;
fc=u/(2*a);
n=377/sqrt(1-(fc/f)^2);
E=sqrt(4*n*Pavg/(a*b));
disp(E,'Peak value of Electric field = ');
```

Scilab code Exa 12.6 Power Transmission

```
clear;
clc;
cc=5.8*10^7, f=4.8*10^9,c=10^-17,Uo=4*%pi*10^-7,Eo
    =10^-9/(36*%pi),Er=2.55,z=60*10^-2,l=4.2*10^-2,b
    =2.6*10^-2,P=1.2*10^3;
n=377/sqrt(Er);
u=3*10^8 /sqrt(Er);
fc=u/(2*l);
ad=c*n/(2*sqrt(1-(fc/f^2)));
Rs=sqrt(%pi*f*Uo/cc);
ac=2*Rs*(.5+(b/l)*(fc/f)^2)/(b*n*sqrt(1-(fc/f)^2));
a=ac;
Pd=P*(%e^(2*a*z) -1);
disp(Pd,'Power dissipiated = ');
```

Scilab code Exa 12.8 Resonator

```
clear;
clc;
a=5*10^-2,b=4*10^-2,c=10*10^-2,C=5.8*10^7,Uo=4*%pi
    *10^-7;
f101=3.335*10^9;
d=sqrt(1/(%pi*f101*Uo*C));
Q=(a*a+c*c)*a*b*c/(d*(2*b*(a^3 + c^3)+a*c*(a*a+c*c))
    );
disp(Q,'Quality factor of TE101 = ');
```

Chapter 13

Antennas

Scilab code Exa 13.1 Dipoles

```
clear;
clc;
format('v',5);
function[P,I]=powerhert(H,P,r,B,dl)
I=H*4*r*%pi/((B*(dl))*sin(P));
P=40*%pi*%pi*I*I*dl*dl;
disp(P*1000,'Power transmit by Hertizian dipole in mWatt');
endfunction
powerhert((5*(10)^-6),%pi/2,2000,(2*%pi),1/25);
function[P,I]=powerhw(H,P,r)
I=H*2*r*%pi*sin(P)/(cos((%pi/2)*cos(P)));R=73;
P=(I*I*R)/2;
disp(P*1000,'Power transmit by Half wave dipole in mWatt');
endfunction
powerhw((5*(10)^-6),%pi/2,2000);
function[P,I]=powerqw(H,P,r)
I=H*2*r*%pi*sin(P)/(cos((%pi/2)*cos(P)));R=36.56;
P=(I*I*R)/2;format('v',4);
disp(P*1000,'Power transmit by Quarterwave monopole
```

```
    in mWatt');
endfunction
powerqw((5*(10)^-6),%pi/2,2000);
function [P,I]=powersingloop(H,r,k);R=192.3;
I=H*r/(%pi*%pi*10*k*k);
P=(I*I*R)/2;
disp(P*1000,'Power transmit by 10 turn loop antena
    in mWatt');
endfunction
powersingloop((5*(10)^-6),2000,1/20);
```

Scilab code Exa 13.2 Dipoles

```
clear;
clc;
format('v',6);
c=3*10^8;
f=50*10^6;
disp(c/(2*f),'Length of halfdipole in meter');
function [P,I]=curpow(E,P,r)
n=120*%pi; R=73;
I=E*2*r*%pi*sin(P)/(n*(cos((%pi/2)*cos(P))));
P=(I*I*R)/2;
disp(I*1000,'Current fed to antenna in mA');
disp(P*1000,'Power radiated by Antenna in mWatt');
endfunction
curpow((10*(10)^-6),%pi/2,500*10^3);
Zl=73+42.5*%i,Zo=75;
T=(Zl-Zo)/(Zl+Zo);
s=(1+abs(T))/(1-abs(T));
disp(s,'Standing wave ratio');
```

Scilab code Exa 13.3 Antennas Chracteristics

```
clear;
clc;
G=(integrate('(sin(P))^3','P',0,%pi))*integrate('1',
    'Q',0,2*%pi)
Gd=4*%pi/G;
disp(Gd)
```

Scilab code Exa 13.4 Antennas Chracteristics

```
clear;
clc;
format('v',7);
G=5;
r=10*10^3;
P=20*10^3;
n=120*%pi;
Gd=10^(G/10);
E=sqrt(n*Gd*P/(2*%pi*r*r));
disp(E,'Electric field intensity at 10 km =');
```

Scilab code Exa 13.5 Antennas Chracteristics

```
clear;
clc;
Umax=2;
Uavg=(1/(4*%pi))*2*integrate('(sin (P))^2','P',0,%pi
   )*integrate('(sin (Q))^3','Q',0,%pi);
D=Umax/Uavg;
disp(D,'Directivity of antenna');
```

Scilab code Exa 13.8 Friis Equation

```
clear;
clc;
c=3*10^8,f=30*10^6,E=2*10^-3;
l=c/f;
n=120*%pi,R=73;
format('v',5);
Gdmax=n/(%pi*R);
format('v',6);
Amax=(l^2 /(4*%pi))*Gdmax;
disp(Amax,'Maximum effective area');
Pr=(E*E*Amax)/(2*n);
disp(Pr*(10^9),'Power rerceived in nWatt')
```

Scilab code Exa 13.9 Friis Equation

```
clear;
clc;
Gt=25,Gr=18,r=200,Pr=5*10^-3 ;
Gdt=10^(Gt/10),Gdr=10^(Gr/10);
Pt=Pr*(4*%pi*r)^2 /(Gdr*Gdt);
disp(Pt,'Minimum power received in Watt =');
```

Scilab code Exa 13.10 Radar Eqution

```
clear;
clc;
c=3*(10)^8, f=3*(10)^9,Aet=9,r1=1.852*(10)^5,r2=4*r1
    ,r3=5.556*10^5,Pr=200*(10)^3,a=20;
l=c/f;
Gdt=4*%pi*Aet/(l*l);
P1=Gdt*Pr/(4*%pi*r1*r1);
```

```
P2=Gdt*Pr/(4*%pi*r2*r2);
disp(P1*1000,'Signal power density at 100nmile in
    mWatt');
disp(P2*1000,'Signal power density at 400nmile in
    mWatt');
Pr=Aet*a*Gdt*Pr/(4*%pi*r3*r3)^2;
disp(Pr*10^12,'Power of reflected signal in picoWatt
    ');
```

Chapter 14

Modern Topics

Scilab code Exa 14.1 Formulae based question

```
clear;
clc;
S11=.85*(cosd(-30)+%i*sind(-30));
S12=.07*(cosd(56)+%i*sind(56));
S21=1.68*(cosd(120)+%i*sind(120));
S22=.85*(cosd(-40)+%i*sind(-40));
Zl=75,Zo=75;
Tl=(Zl-Zo)/(Zl+Zo);
Ti=S11+ (S12*S21*Tl)/(1-S22*Tl);
disp(Ti,'Input reflection coefficient=')
```

Scilab code Exa 14.2 Optical fibre

```
clear;
clc;
format('v',6)
d=80*(10)^-6;
n1=1.62,NA=.21,L=8*(10)^-7 ;
```

```
P=asind(NA);
disp(P,'Acceptance angle');
n2=sqrt(n1^2 - NA^2);
disp(n2,'Refractive index');
V=(%pi*d/L)*sqrt(n1^2 - n2^2);
disp(V,'No of modes');
```

Scilab code Exa 14.3 Optical fibre

```
clear;
clc;
a=.25;
P=1-.4;
l=(10/a)*log10(1/P);
disp(l,'Distance travelled in Km');
```