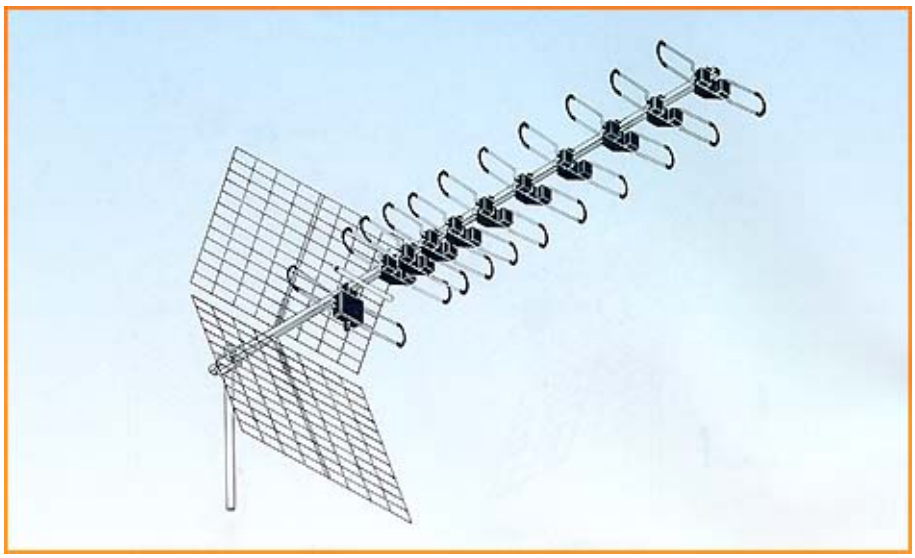
DIPARTIMENTO DI
ELETTROTECNICA
ED ELETTRONICA

CORSO DI LAUREA IN INGEGNERIA ELETTRONICA

ESAME DI ANTENNE

ANNO ACCADEMICO 1999 / 2000

PROGRAMMI IN MATLAB



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Eseguito da :

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Questa relazione potrete trovarla in formato HTML al sito : http://digilander.iol.it/marinel/vito/antenne/antenne.htm

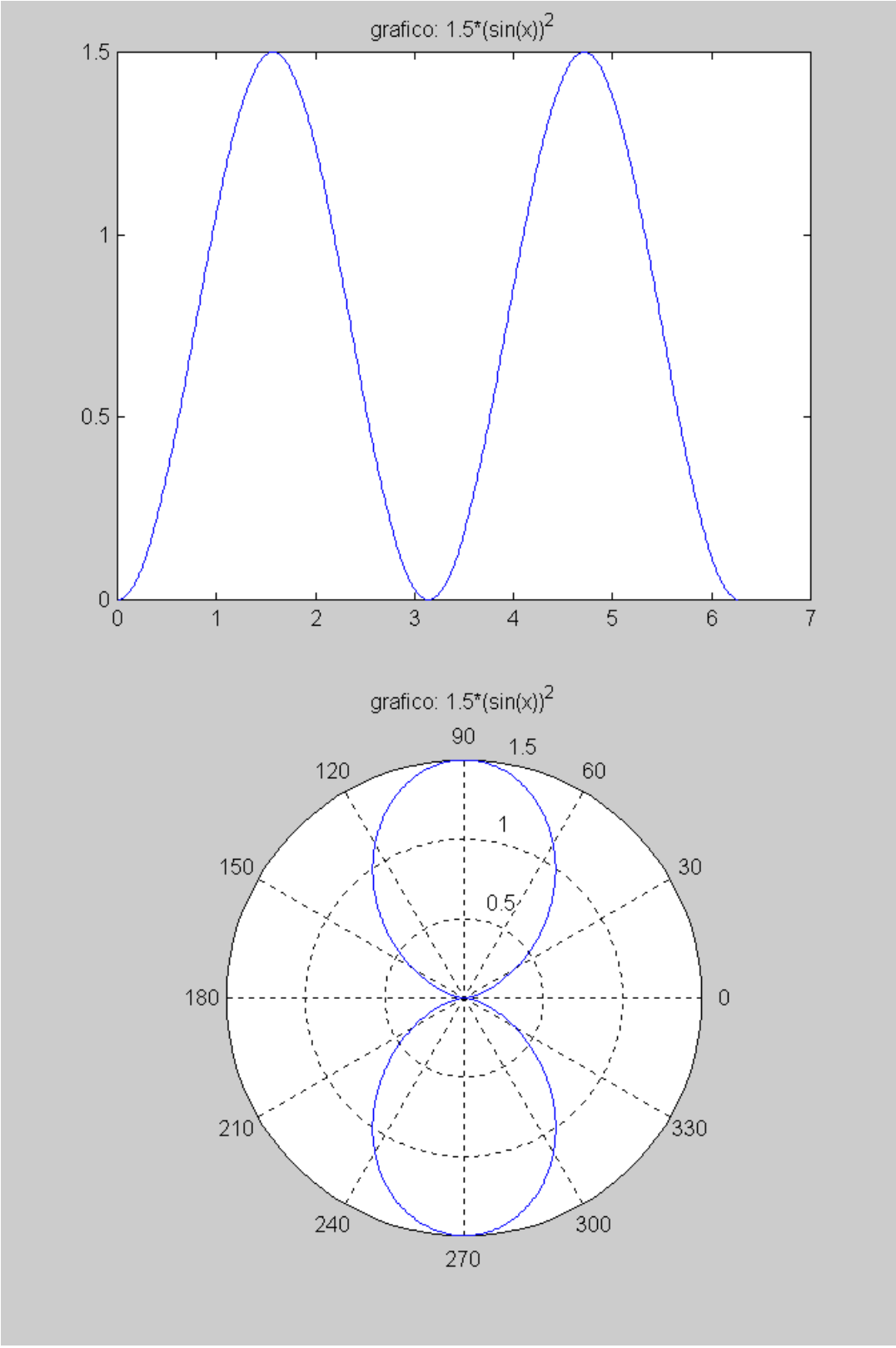
Sempre nel sito : http://digilander.iol.it/marinel potrete trovare altro materiale didattico.

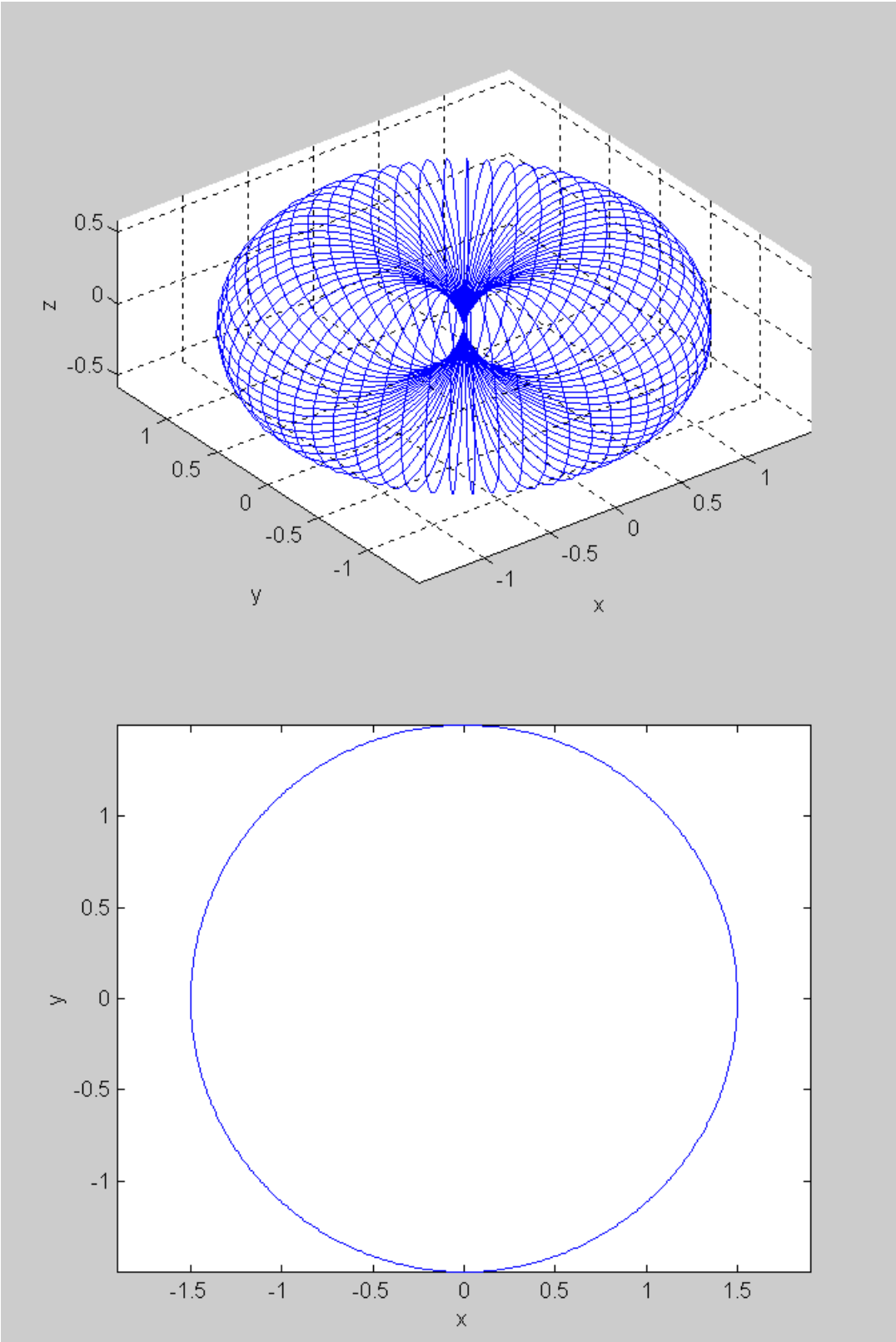
Dipolo.m

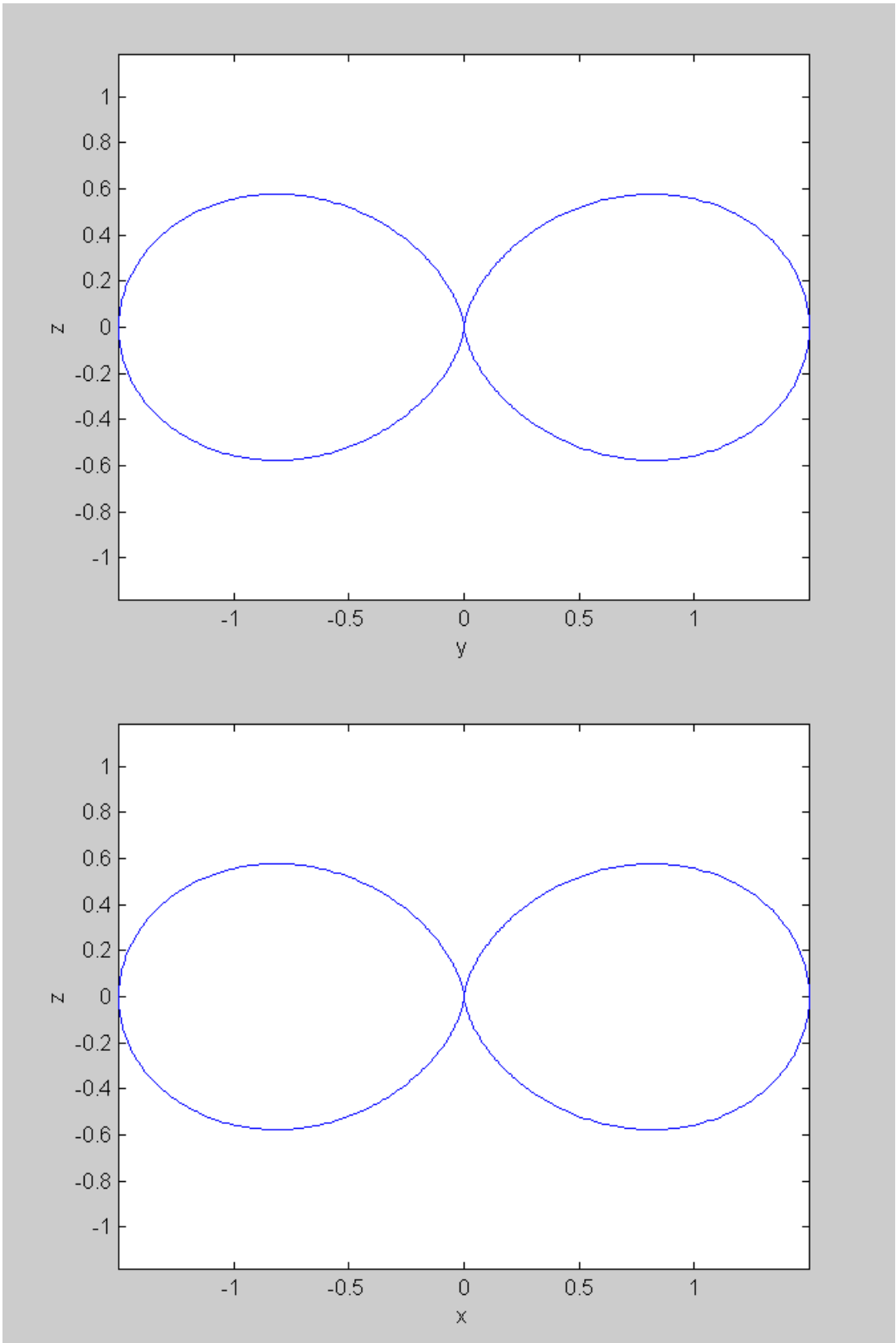
```
% disegno del grafico della direttività di una antenna filiforme a lambda/2

clear all
close all
x=0.01:0.01:2*pi-0.01;
yd=1.5*(sin(x)).^2;
plot(x,yd)
title('grafico: 1.5*(sin(x))^2')
zoom
clear all
phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RD=1.5*(sin(th(i)))^2;
         [xd(h),yd(h),zd(h)]=sph2cart(phi(j),pi/2-th(i),RD);
      end
   end
end
clear TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRD=1.5*(sin(th(i)))^2;
         [xxd(h),yyd(h),zzd(h)]=sph2cart(phi(j),pi/2-th(i),RRD);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRD=1.5*(sin(th(i)))^2;
         [xxxd(h),yyyd(h),zzzd(h)]=sph2cart(phi(j),pi/2-th(i),RRRD);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRRD=1.5*(sin(th(i)))^2;
         [xxxxd(h),yyyyd(h),zzzzd(h)]=sph2cart(phi(j),pi/2-th(i),RRRRD);
      end
```

```
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      RD(i)=1.5*(sin(TH(i)))^2;
   end
end

figure
polar(TH,RD);
title('grafico: 1.5*(sin(x))^2')
figure
plot3(xd,yd,zd)
grid
xlabel('x')
ylabel('y')
zlabel('z')
axis equal
figure
plot(xxd,yyd)
xlabel('x')
ylabel('y')
axis equal
figure
plot(yyyyd,zzzzd)
xlabel('y')
ylabel('z')
axis equal
figure
plot(xxxd,zzzd)
xlabel('x')
ylabel('z')
axis equal
```

Esecuzione del programma




0.5
0
-0.5
z
1
0.5
0
-0.5
-1
y
1
0.5
0
-0.5
-1
x
1
0.5
0
-0.5
-1
y
-1.5
-1
-0.5
0
0.5
1
1.5
x

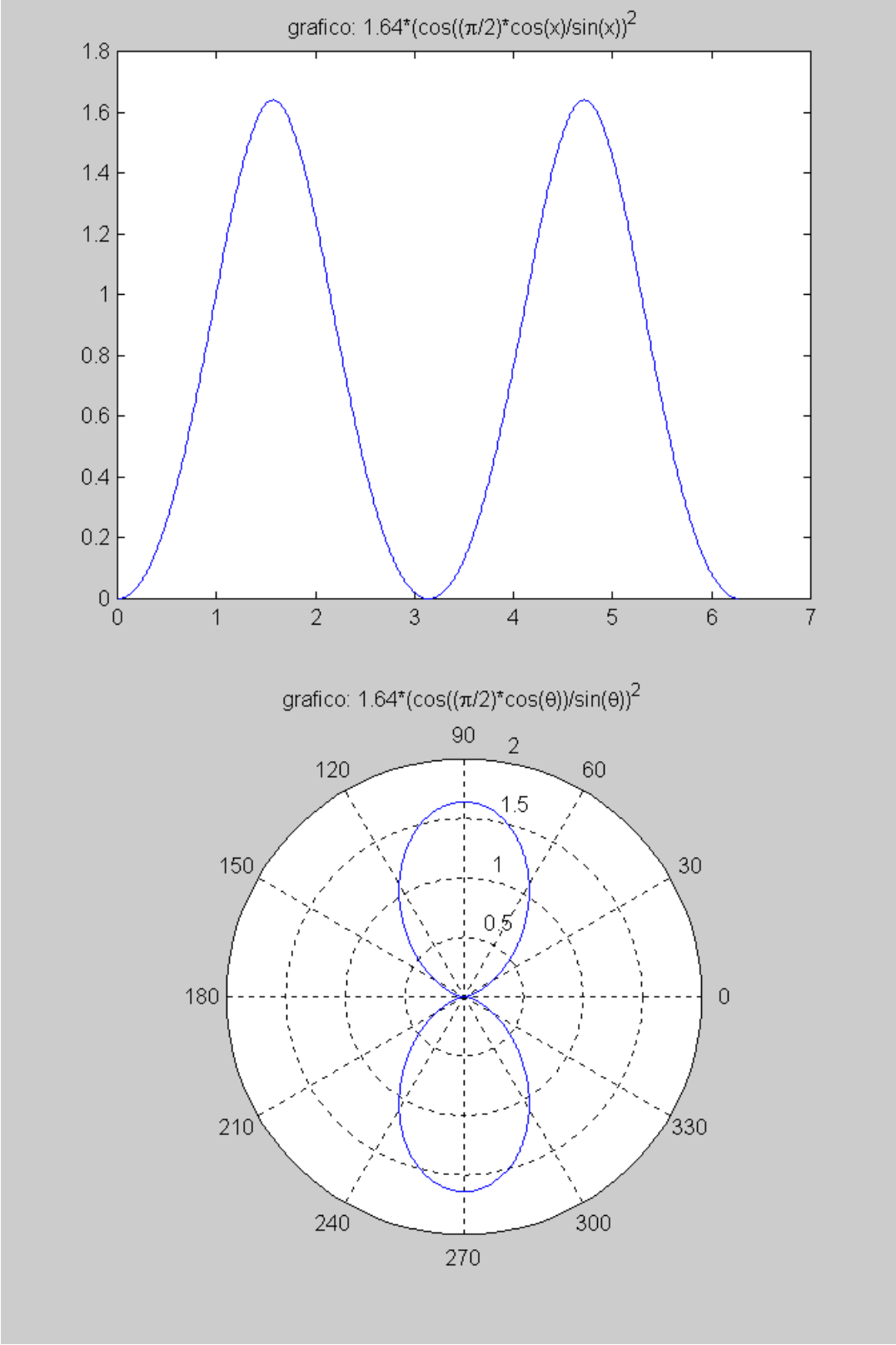

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
z
-1
-0.5
0
0.5
1
y
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
z
-1
-0.5
0
0.5
1
x

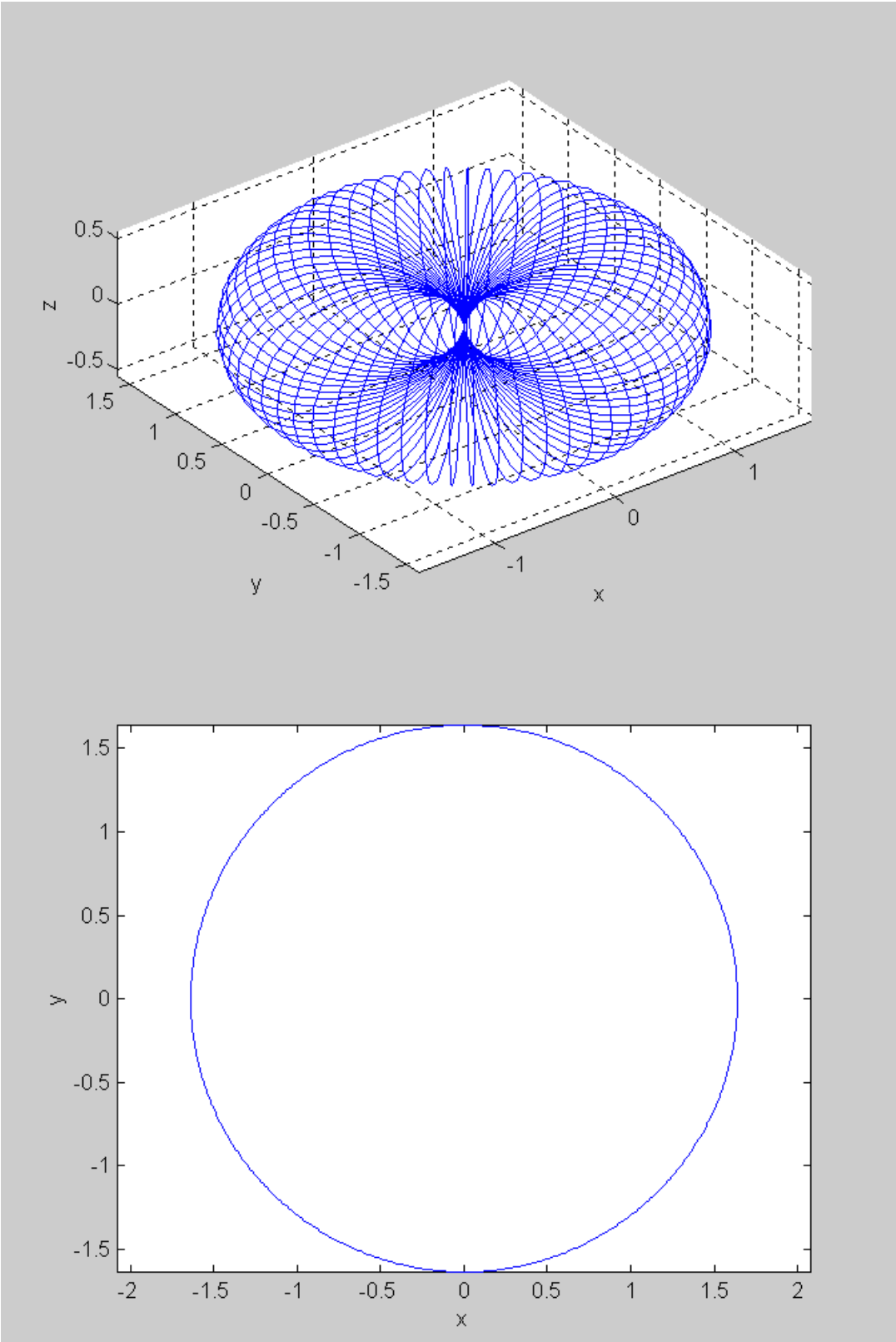
Filiforme.m

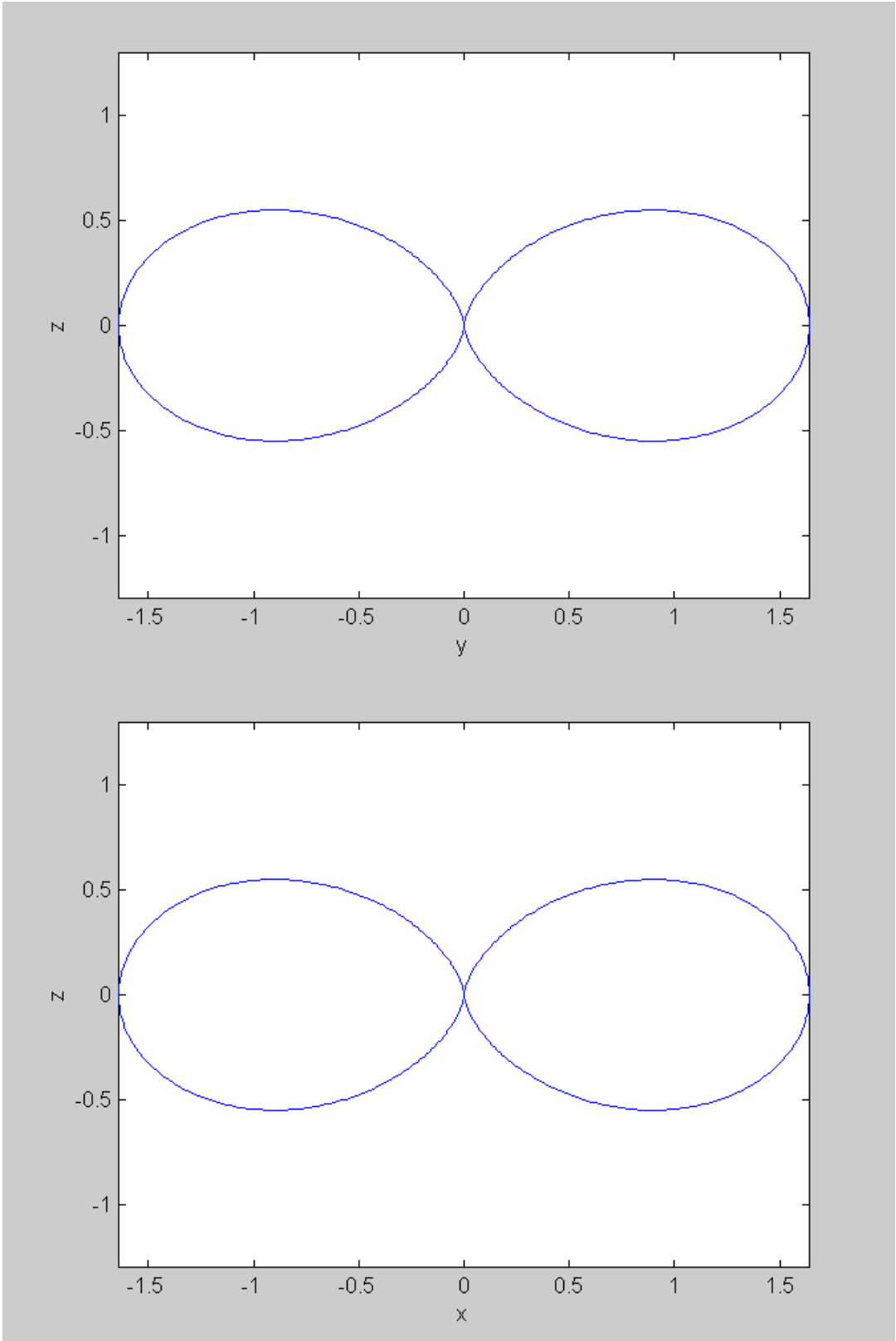
```
% disegno del grafico della direttività di una antenna filiforme a lambda/2

clear all
close all
x=0.01:0.01:2*pi-0.01;
y=1.64*(cos((pi/2).*cos(x))./sin(x)).^2;
plot(x,y)
title('grafico: 1.64*(cos((\pi/2)*cos(x)/sin(x))^2')
zoom
clear all
phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         R=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
clear R TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
```

```
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      R(i)=1.64*(cos((pi/2)*cos(TH(i)))/sin(TH(i)))^2;
   end
end

figure
polar(TH,R);
title('grafico: 1.64*(cos((\pi/2)*cos(\theta))/sin(\theta))^2')
figure
plot3(x,y,z)
grid
xlabel('x')
ylabel('y')
zlabel('z')
axis equal
figure
plot(xx,yy)
xlabel('x')
ylabel('y')
axis equal
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
axis equal
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
axis equal
```

Esecuzione del programma




0.5
0
-0.5
z
1.5
1
0.5
0
-0.5
-1
-1.5
y
-1
0
1
x
1.5
1
0.5
0
-0.5
-1
-1.5
y
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
x

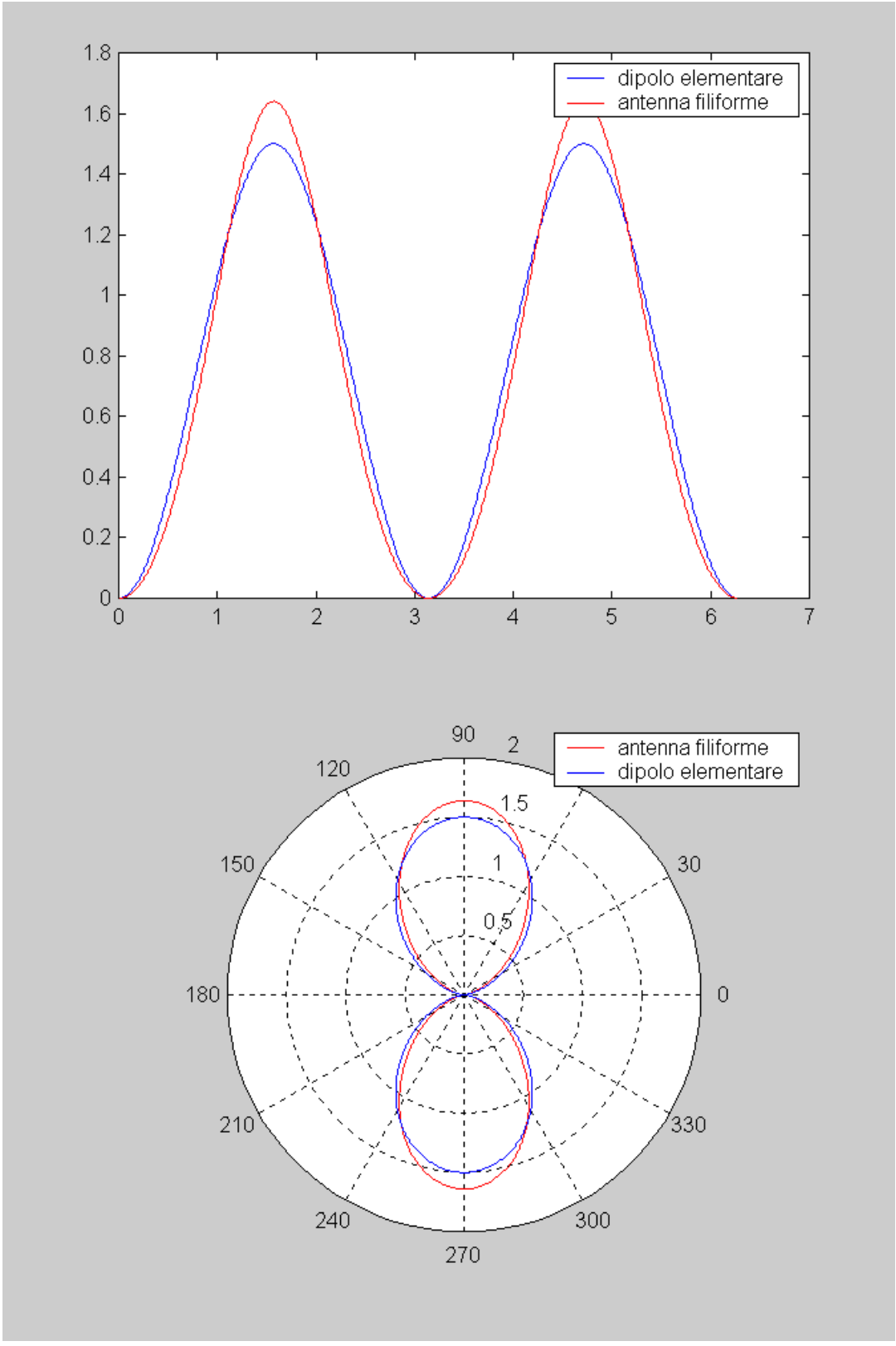

1
0.5
0
-0.5
-1
z
-1.5
-1
-0.5
0
0.5
1
1.5
y
1
0.5
0
-0.5
-1
z
-1.5
-1
-0.5
0
0.5
1
1.5
x

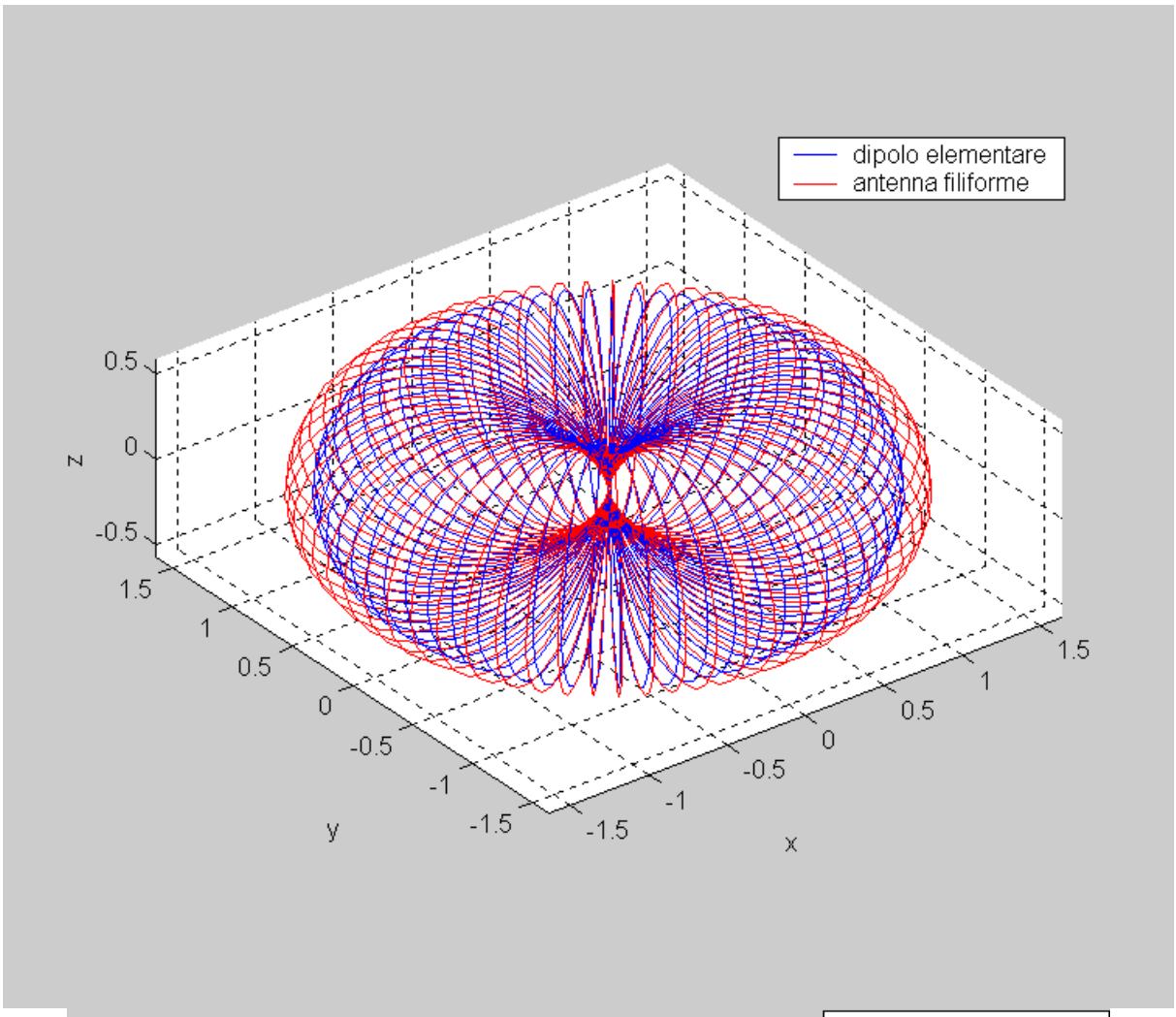
Antenne.m

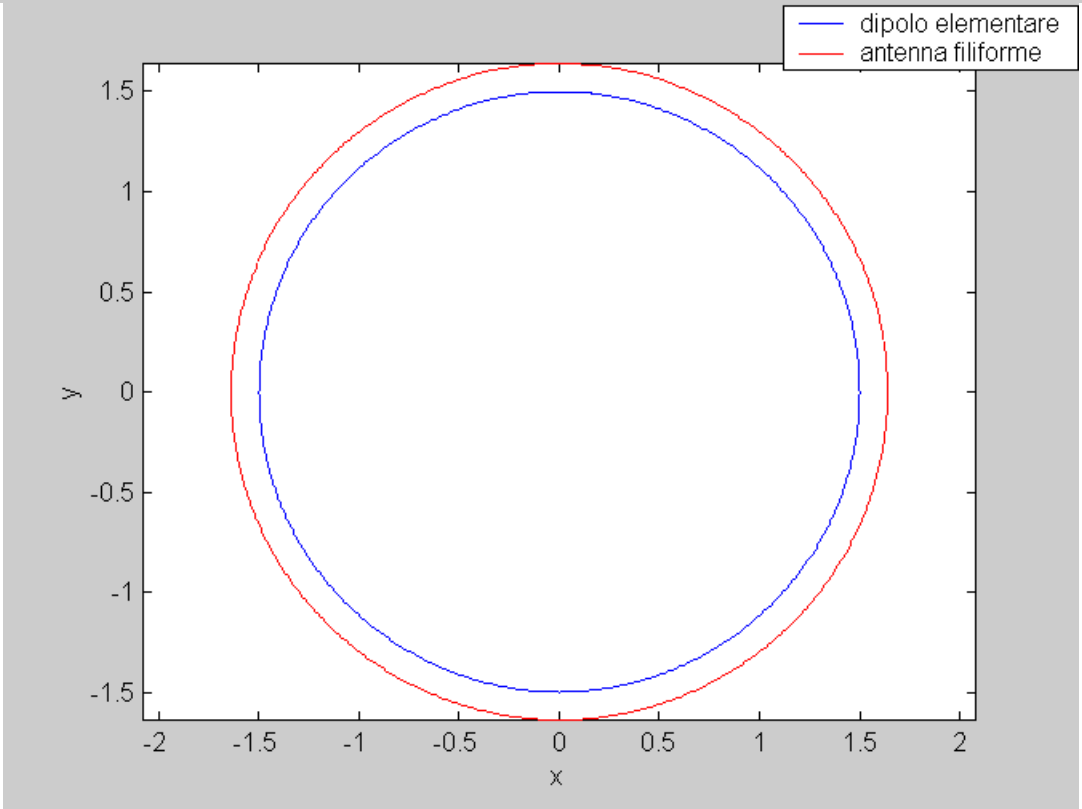
```
% disegno del grafico della direttività di una antenna filiforme a lambda/2
% e di un dipolo
% confronti

clear all
close all
x=0.01:0.01:2*pi-0.01;
y=1.64*(cos((pi/2).*cos(x))./sin(x)).^2;
yd=1.5*(sin(x)).^2;
plot(x,yd,x,y,'r')
legend('dipolo elementare','antenna filiforme');
zoom
clear all
phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         R=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         RD=1.5*(sin(th(i)))^2;
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
         [xd(h),yd(h),zd(h)]=sph2cart(phi(j),pi/2-th(i),RD);
      end
   end
end
clear R TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         RRD=1.5*(sin(th(i)))^2;
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
         [xxd(h),yyd(h),zzd(h)]=sph2cart(phi(j),pi/2-th(i),RRD);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         RRRD=1.5*(sin(th(i)))^2;
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
         [xxxd(h),yyyd(h),zzzd(h)]=sph2cart(phi(j),pi/2-th(i),RRRD);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
```

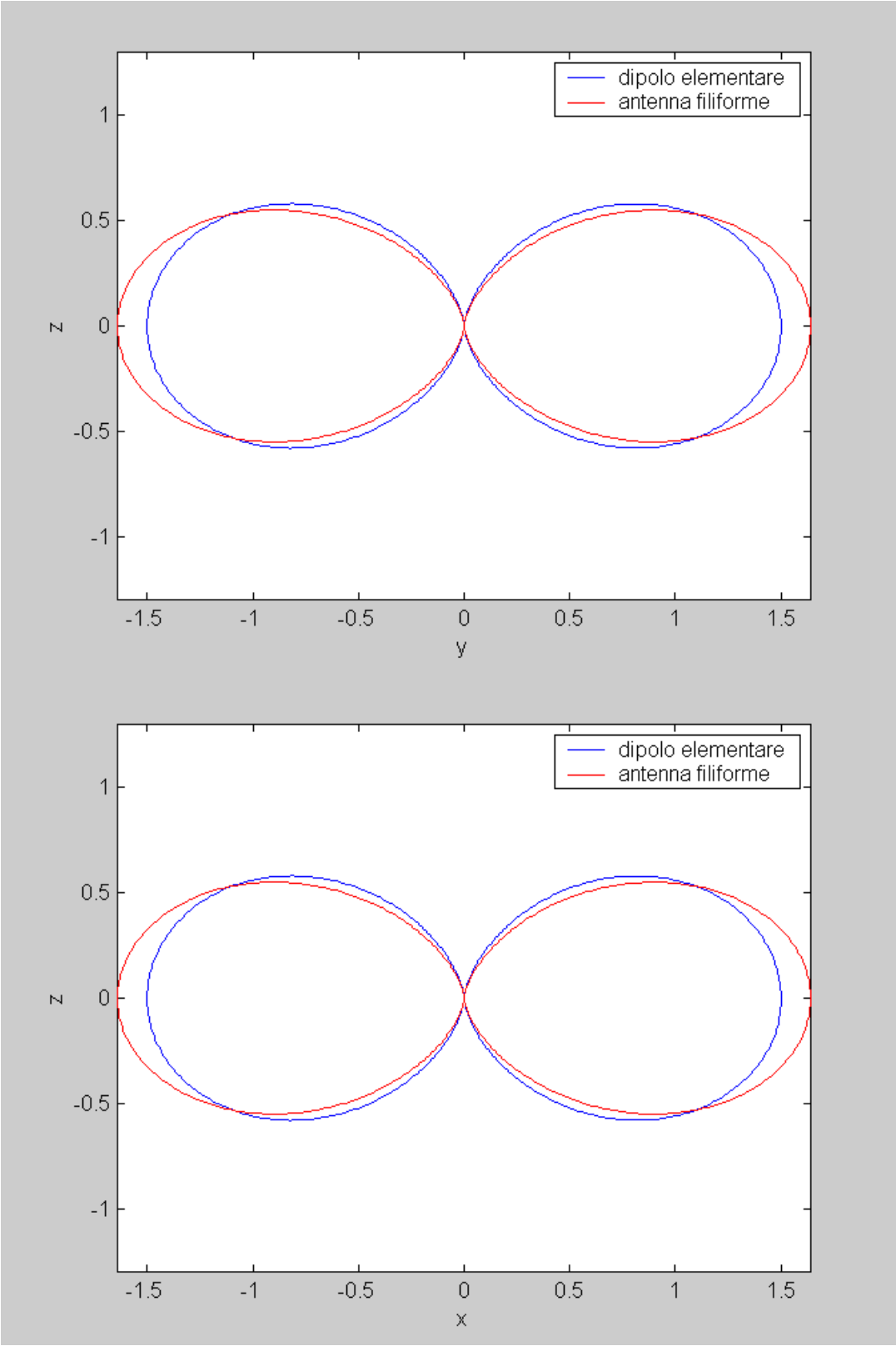
```
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=1.64*(cos((pi/2)*cos(th(i)))/sin(th(i)))^2;
         RRRRD=1.5*(sin(th(i)))^2;
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
         [xxxxd(h),yyyyd(h),zzzzd(h)]=sph2cart(phi(j),pi/2-th(i),RRRRD);
      end
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      R(i)=1.64*(cos((pi/2)*cos(TH(i)))/sin(TH(i)))^2;
      RD(i)=1.5*(sin(TH(i)))^2;
   end
end

figure
polar(TH,R,'r');
hold on
polar(TH,RD);
hold off
legend('antenna filiforme','dipolo elementare');
figure
plot3(xd,yd,zd,x,y,z,'r')
grid
legend('dipolo elementare','antenna filiforme');
xlabel('x')
ylabel('y')
zlabel('z')
axis equal
figure
plot(xxd,yyd,xx,yy,'-r')
xlabel('x')
ylabel('y')
legend('dipolo elementare','antenna filiforme');
axis equal
figure
plot(yyyyd,zzzzd,yyyy,zzzz,'r')
xlabel('y')
ylabel('z')
legend('dipolo elementare','antenna filiforme');
axis equal
figure
plot(xxxd,zzzd,xxx,zzz,'r')
xlabel('x')
ylabel('z')
legend('dipolo elementare','antenna filiforme');
axis equal
```

Esecuzione del programma




dipolo elementare
antenna filiforme
z
0.5
0
-0.5
1.5
1
0.5
0
-0.5
-1
-1.5
y
-1.5
-1
-0.5
0
0.5
1
1.5
x


dipolo elementare
antenna filiforme
1.5
1
0.5
0
-0.5
-1
-1.5
y
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
x


dipolo elementare
antenna filiforme
z
y
x
1
0.5
0
-0.5
-1
-1.5
1.5

broadside.m

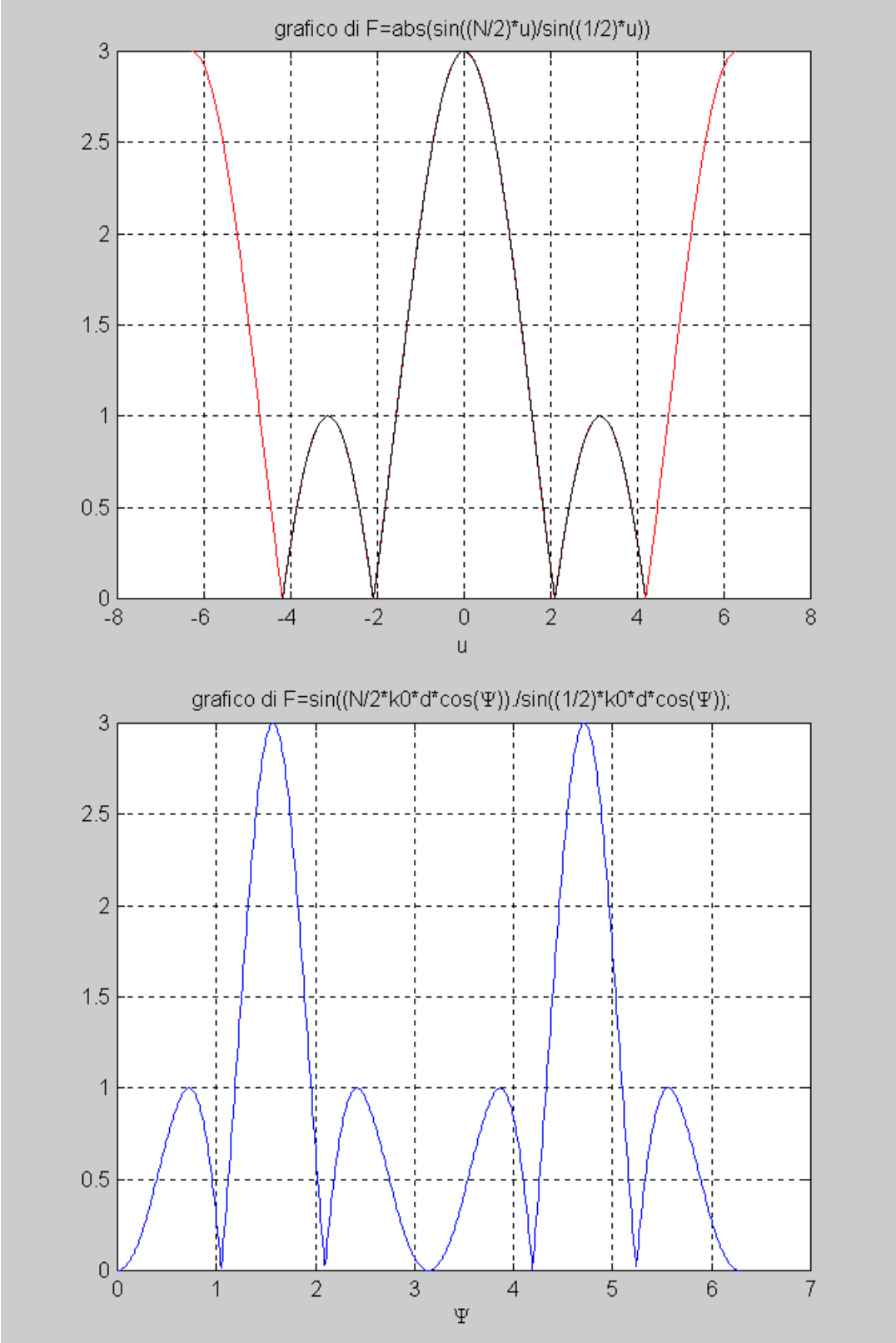
```
% disegno del grafico del fattore di schiera F e del corrispondente
% fattore di irradiazione totale ftot
% delle schiere di antenne filiformi broadside

clear all
close all
lm=1;
N=3;
d=((N-1)/N)*lm;
kod=(2*pi/lm)*d;
u=-kod:0.01:kod;
u1=-2*pi:0.01:2*pi;
y=abs(sin((N/2)*u)./sin((1/2)*u));
y1=abs(sin((N/2)*u1)./sin((1/2)*u1));
plot(u1,y1,'r',u,y,'k')
title('grafico di F=abs(sin((N/2)*u)/sin((1/2)*u))')
xlabel('u')
zoom
grid
clear y
x=0:0.01:2*pi;
y=abs(sin((N/2)*kod*cos(x))./sin((1/2)*kod*cos(x)));
figure
plot(x,y)
title('grafico di F=sin((N/2*k0*d*cos(\Psi))./sin((1/2)*k0*d*cos(\Psi));')
xlabel('\Psi')
zoom
grid
clear x y

phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*sin(th(i))*...
            cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*sin(th(i))*...
            cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end

clear R TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
```

```
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*...
             kod*sin(th(i))*cos(phi(j)));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear R TH phi th
phi=0;       % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*sin(th(i))*...
             cos(phi(j)));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
             sin(th(i))*cos(phi(j)));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      R(i)=sin((N/2)*kod*cos(TH(i)))/sin((1/2)*kod*cos(TH(i)));
   end
end

figure
polar(TH,R);
title('grafico: sin((N/2)*ko*d*cos(\Psi))/sin((1/2)*ko*d*cos(\Psi))')
figure
plot(xx,yy)
xlabel('x')
ylabel('y')
title('FATTORE DI SCHIERA');
axis equal
grid
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
title('FATTORE DI SCHIERA');
axis equal
grid
```

```
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
title('FATTORE DI SCHIERA');
axis equal
grid
%
%
%

figure
plot3(x,y,z)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('ftot');

clear x y R RR RRR RRRR xx xxx xxxx yy yyy yyyy zz zzz zzzz TH phi th

phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=abs(sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*...
             kod*sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=abs(sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*...
             kod*sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=abs(sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
             sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end
```

```
clear R TH
figure
plot(xx,yy)
xlabel('x')
ylabel('y')
title('fattore di irradiazione totale');
axis equal
grid
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
title('fattore di irradiazione totale');
axis equal
grid
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
title('fattore di irradiazione totale');
axis equal
grid
```

Esecuzione del programma



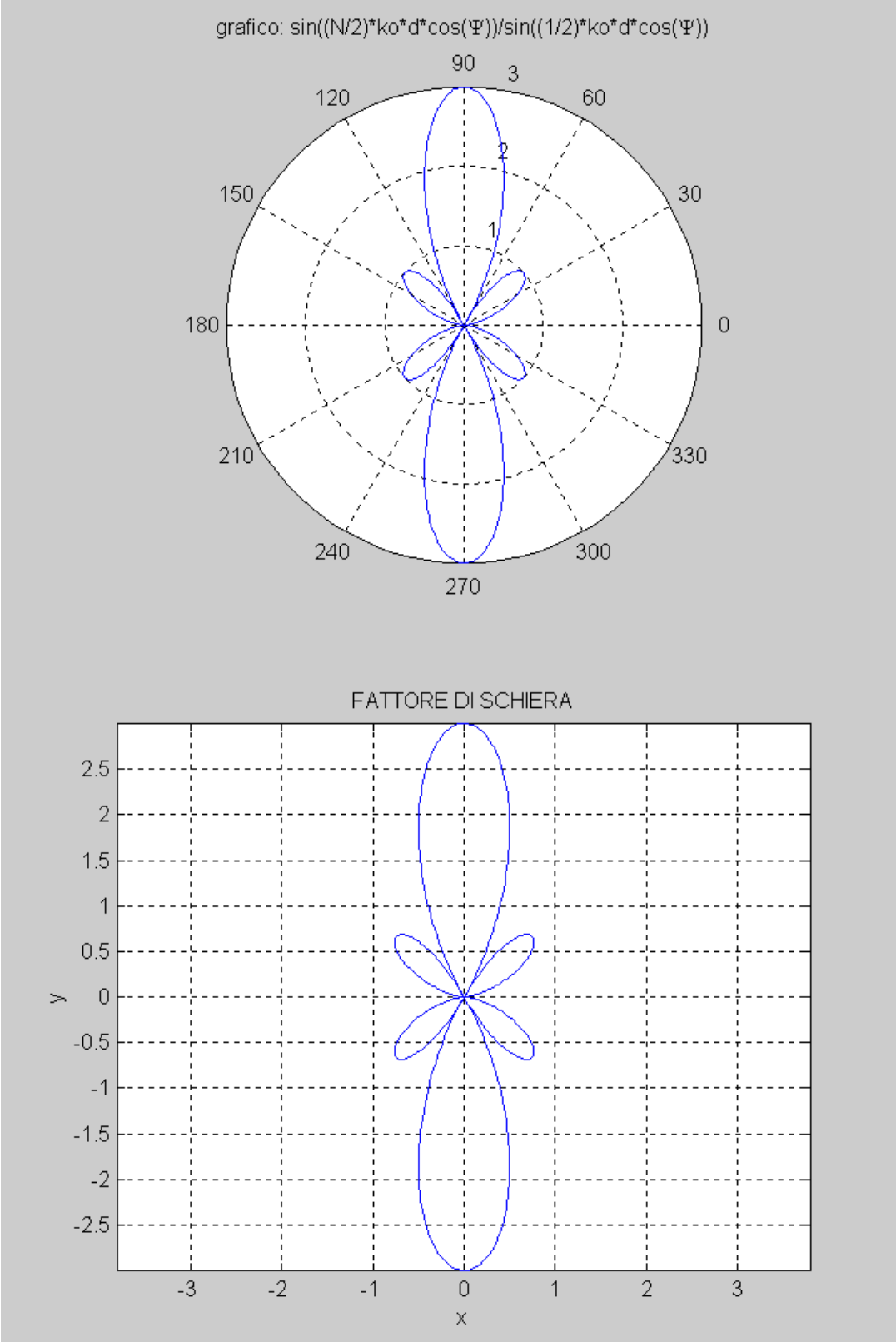
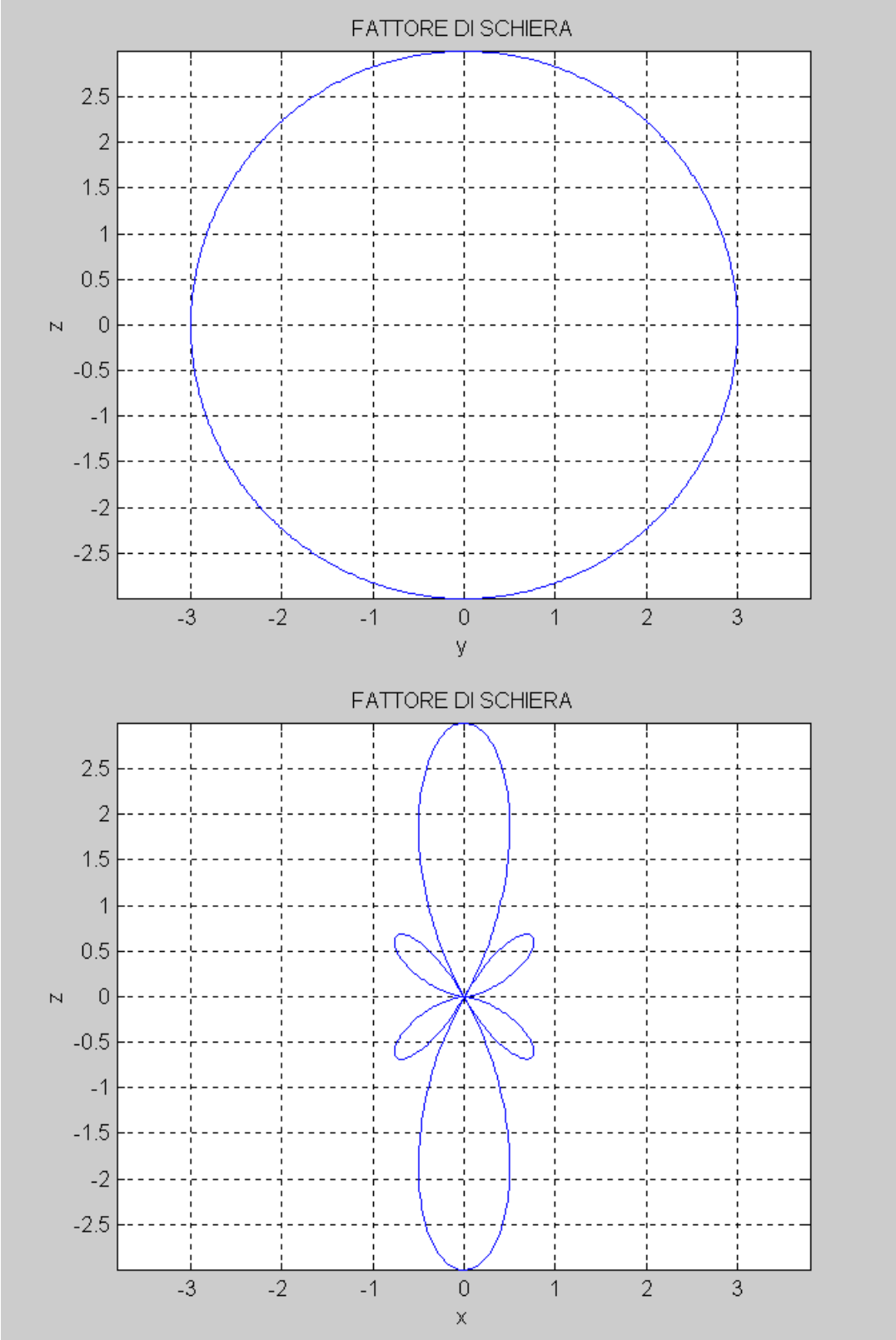
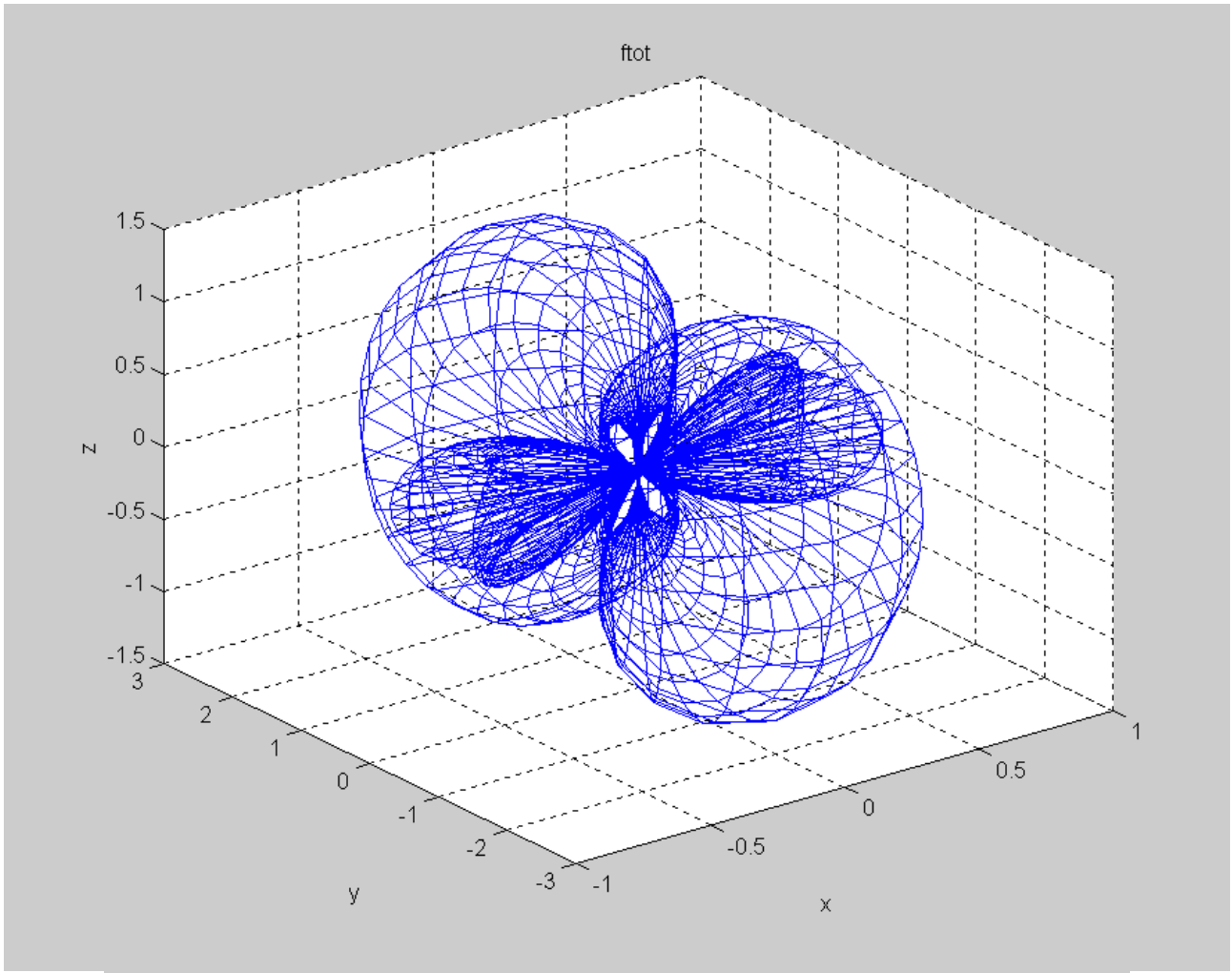
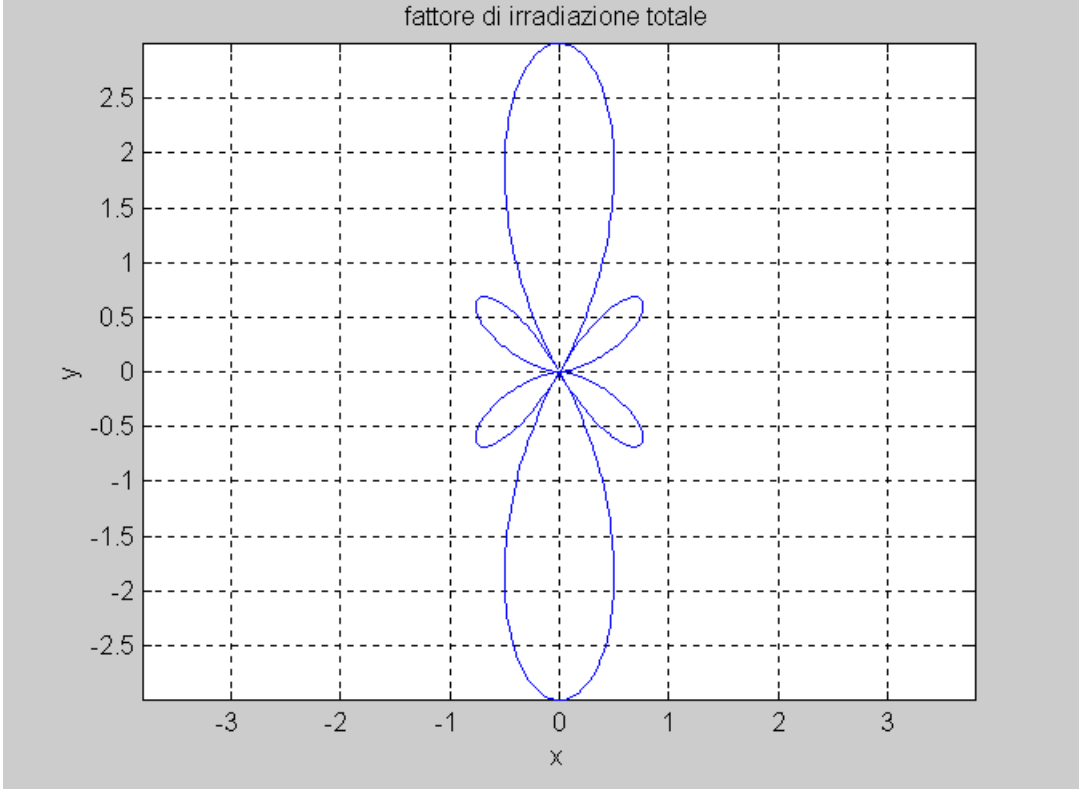
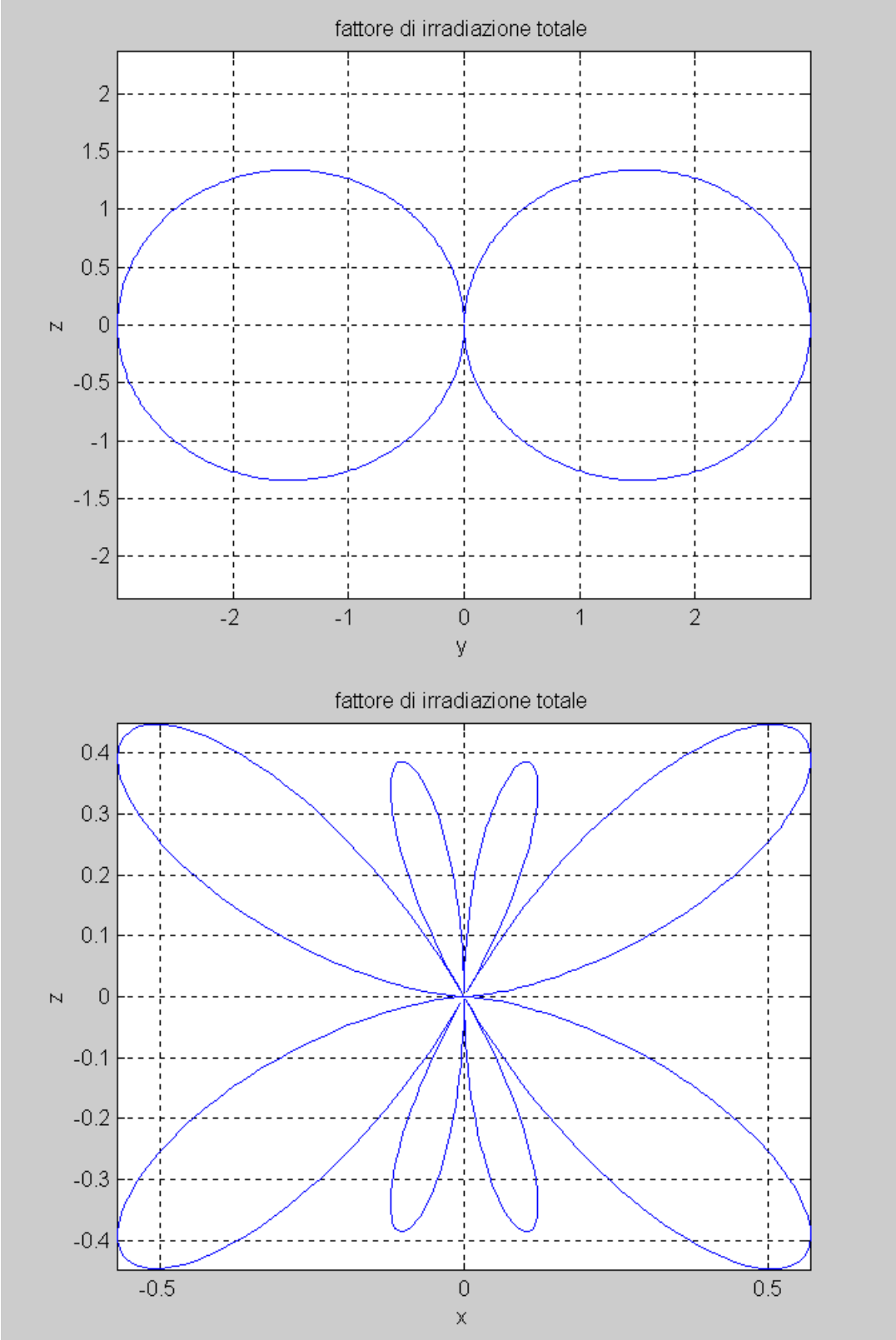


grafico: sin((N/2)*ko*d*cos(Ψ))/sin((1/2)*ko*d*cos(Ψ))
90
3
120
60
2
150
30
1
180
0
210
330
240
300
270
FATTORE DI SCHIERA
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
y
-3
-2
-1
0
1
2
3
x


FATTORE DI SCHIERA
z
y
FATTORE DI SCHIERA
z
x


ftot
z
y
x


fattore di irradiazione totale
y
x


fattore di irradiazione totale
z
y
fattore di irradiazione totale
z
x

endfire.m

```
% disegno del grafico del fattore di schiera F e del corrispondente
% fattore di irradiazione totale ftot
% delle schiere di antenne filiformi endfire

clear all
close all
lm=1;
N=3;
d=((N-1)/N)*(lm/2);
kod=(2*pi/lm)*d;
u=-kod:0.01:kod-0.01;
u1=-2*pi:0.01:2*pi;
y=abs(sin((N/2)*(u-kod))./sin((1/2)*(u-kod)));
y1=abs(sin((N/2)*(u1-kod))./sin((1/2)*(u1-kod)));
plot(u1,y1,'r',u,y,'k')
title('grafico di F=abs(sin((N/2)*(u-ko*d))/sin((1/2)*(u-ko*d)))')
xlabel('u')
zoom
grid
clear y
x=0.01:0.01:2*pi;
y=abs(sin((N/2)*kod*(cos(x)-1))./sin((1/2)*kod*(cos(x)-1)));
figure
plot(x,y)
title('grafico di F=sin((N/2)*k0*d*(cos(\Psi)-1))/sin((1/2)*k0*d*(cos(\Psi)-1))');
xlabel('\Psi')
zoom
grid
clear x y
TH=0.01:0.01:2*pi-0.01;
for i=1:length(TH)
   if cos(TH(i))~=1
      R(i)=abs(sin((N/2)*kod*(cos(TH(i))-1))/sin((1/2)*kod*(cos(TH(i))-1)));
   end
end

figure
polar(TH,R);
title('grafico: sin((N/2)*ko*d*(cos(\Psi)-1))/sin((1/2)*ko*d*(cos(\Psi)-1))')
xlabel('\Psi')
clear R

phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         R=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
figure
no=gcf;
plot(x,y,'r')
grid
```

```
figure
plot(y,z,'r')
grid
figure
plot(x,z,'r')
grid

h=0;
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         R=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [x1(h),y1(h),z1(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
figure
noo=gcf;
plot(x1,y1,'r')
grid
figure
plot(y1,z1,'r')
grid
figure
plot(x1,z1,'r')
grid

x=[x,x1];
y=[y,y1];
z=[z,z1];
clear R phi th

phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         Rd=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
            (sin(th(i))*cos(phi(j))-1)));
         [xd(h),yd(h),zd(h)]=sph2cart(phi(j),pi/2-th(i),Rd);
      end
   end
end
figure(no)
hold on
plot(xd,yd)
hold off
xlabel('x')
ylabel('y')
title('curve di livello verticali: F,ftot (in rosso)');
grid
figure(no+1)
hold on
plot(yd,zd)
hold off
xlabel('y')
ylabel('z')
title('curve di livello verticali: F,ftot (in rosso)');
```

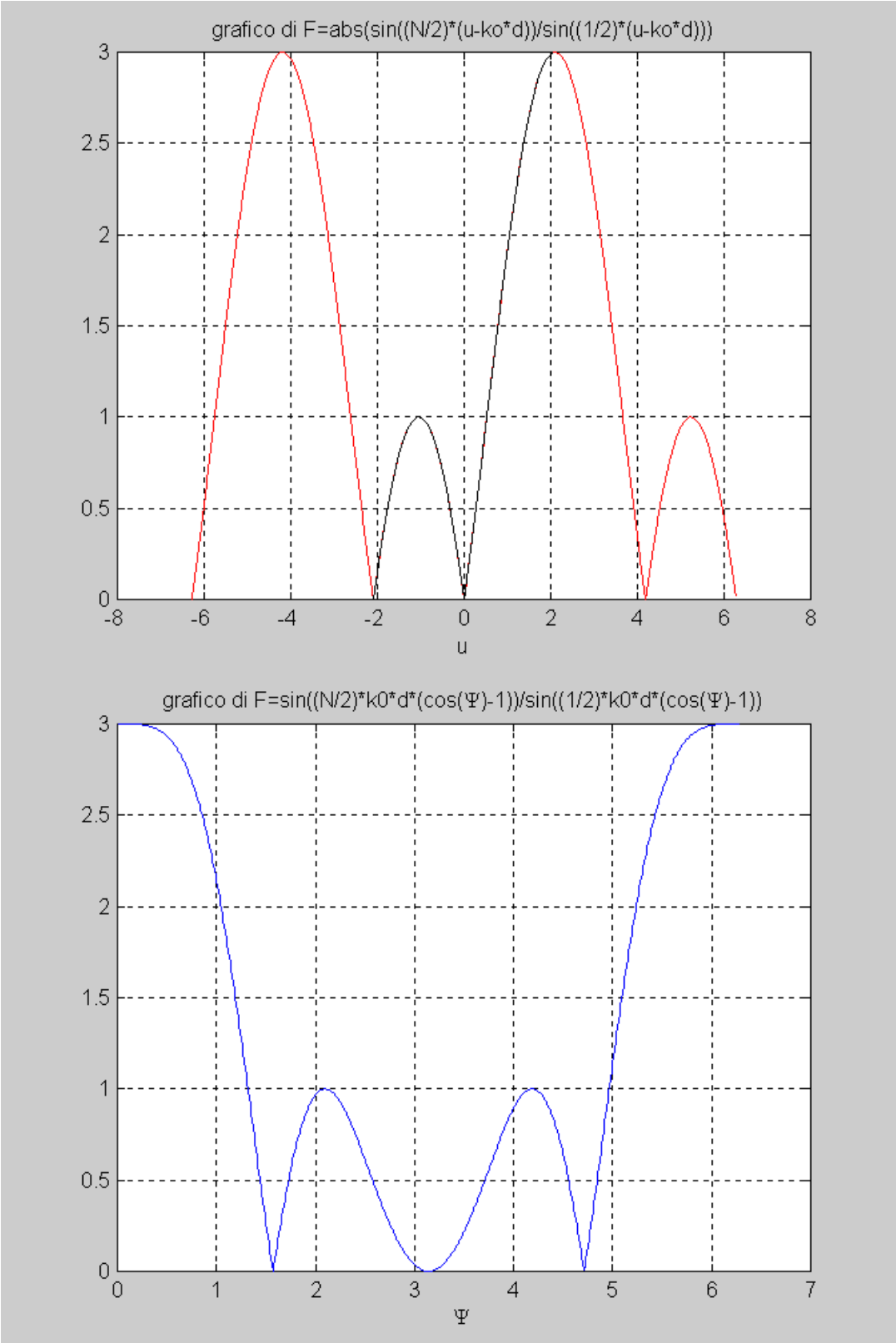
```
grid
figure(no+2)
hold on
plot(xd,zd)
hold off
xlabel('x')
ylabel('z')
title('curve di livello verticali: F,ftot (in rosso)');
grid

h=0;
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         Rd=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
            (sin(th(i))*cos(phi(j))-1)));
         [xd1(h),yd1(h),zd1(h)]=sph2cart(phi(j),pi/2-th(i),Rd);
      end
   end
end
figure(noo)
hold on
plot(xd1,yd1)
hold off
xlabel('x')
ylabel('y')
grid
title('curve di livello orizzontali: F,ftot (in rosso)');
figure(noo+1)
hold on
plot(yd1,zd1)
hold off
xlabel('y')
ylabel('z')
grid
title('curve di livello orizzontali: F,ftot (in rosso)');
figure(noo+2)
hold on
plot(xd1,zd1)
hold off
xlabel('x')
ylabel('z')
grid
title('curve di livello orizzontali: F,ftot (in rosso)');

xd=[xd,xd1];
yd=[yd,yd1];
zd=[zd,zd1];
clear Rd phi th


phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         RR=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1)));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
```

```
   end
end
clear phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 %& cos(phi(j))~=1
         h=h+1;
         RRR=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1)));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R phi th
phi=pi/2;             % è il TH del MATLAB
th=0:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         RRRR=(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
            (sin(th(i))*cos(phi(j))-1)));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end

clear R
figure
n1=gcf;
plot(xx,yy)
xlabel('x')
ylabel('y')
axis equal
grid
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
axis equal
grid
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
axis equal
grid
%
%
%
figure
plot3(xd,yd,zd)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F');
```

```
figure
plot3(x,y,z)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('ftot');

figure
plot3(xd,yd,zd,x,y,z,'r')
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F,ftot(in rosso)');

clear RR RRR RRRR xx xxx xxxx yy yyy yyyy zz zzz zzzz phi th

phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         RR=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear phi th
phi=0;                % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear phi th
phi=pi/2;             % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(phi(j))~=1
         h=h+1;
         RRRR=abs(sin((N/2)*kod*(sin(th(i))*cos(phi(j))-1))/sin((1/2)*kod*...
             (sin(th(i))*cos(phi(j))-1))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end

clear R
figure(n1)
hold on
```

```
plot(xx,yy,'.r')
hold off
xlabel('x')
ylabel('y')
title('F,ftot (in rosso)');
axis equal
grid
figure(n1+1)
hold on
plot(yyyy,zzzz,'r')
xlabel('y')
ylabel('z')
title('F,ftot (in rosso)');
axis equal
grid
hold off
figure(n1+2)
hold on
plot(xxx,zzz,'r')
xlabel('x')
ylabel('z')
title('F,ftot (in rosso)');
axis equal
grid
hold off
```

Esecuzione del programma



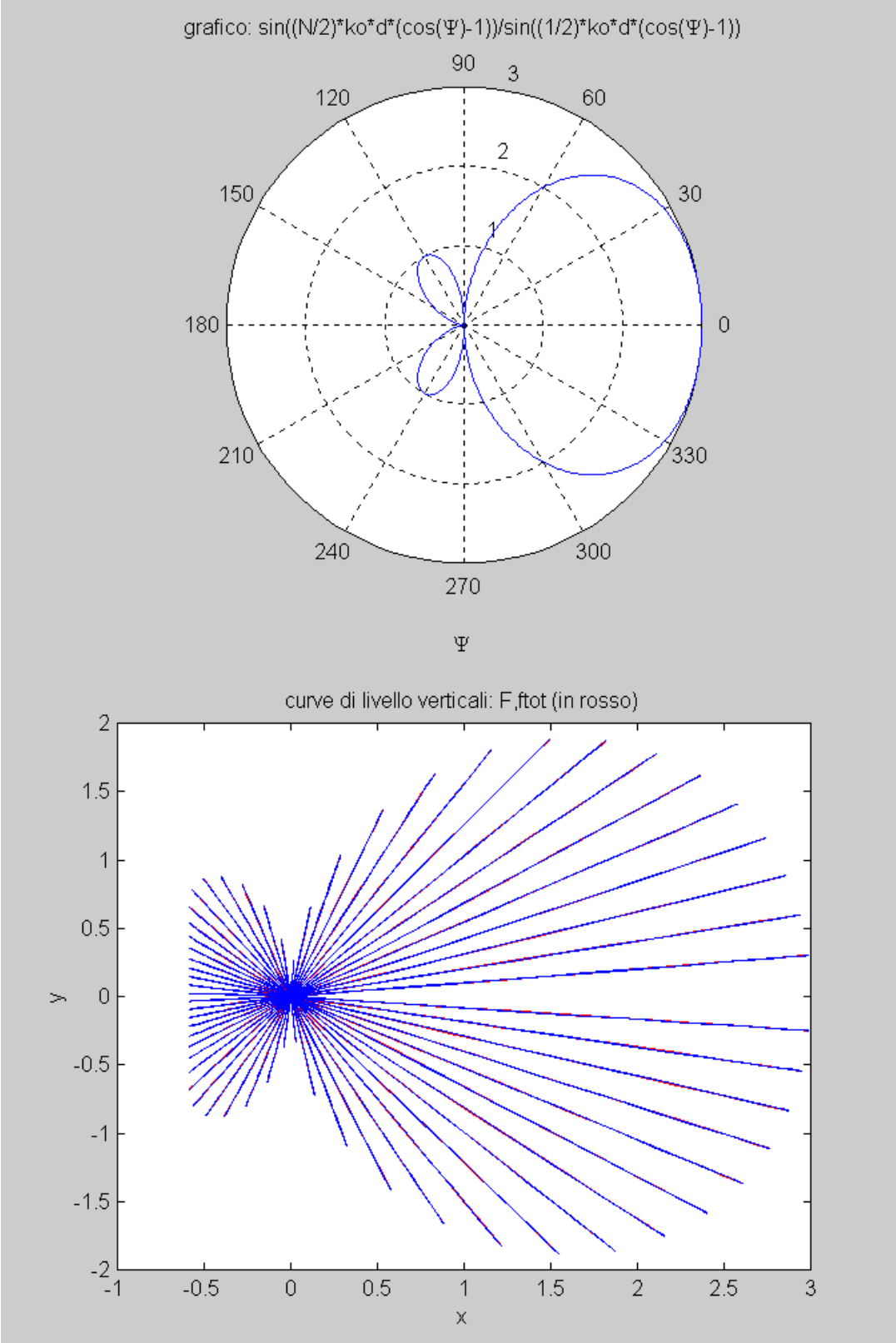
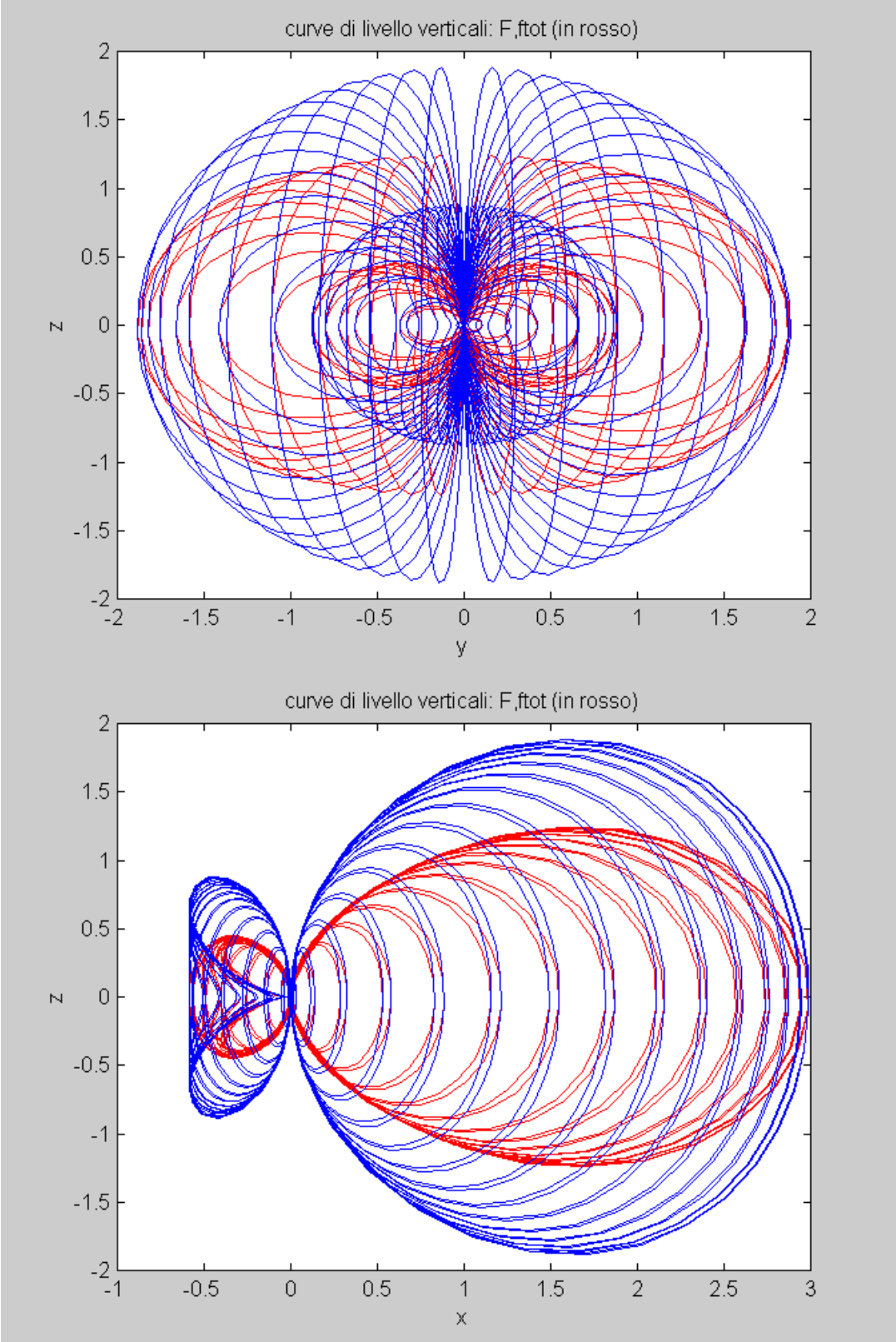
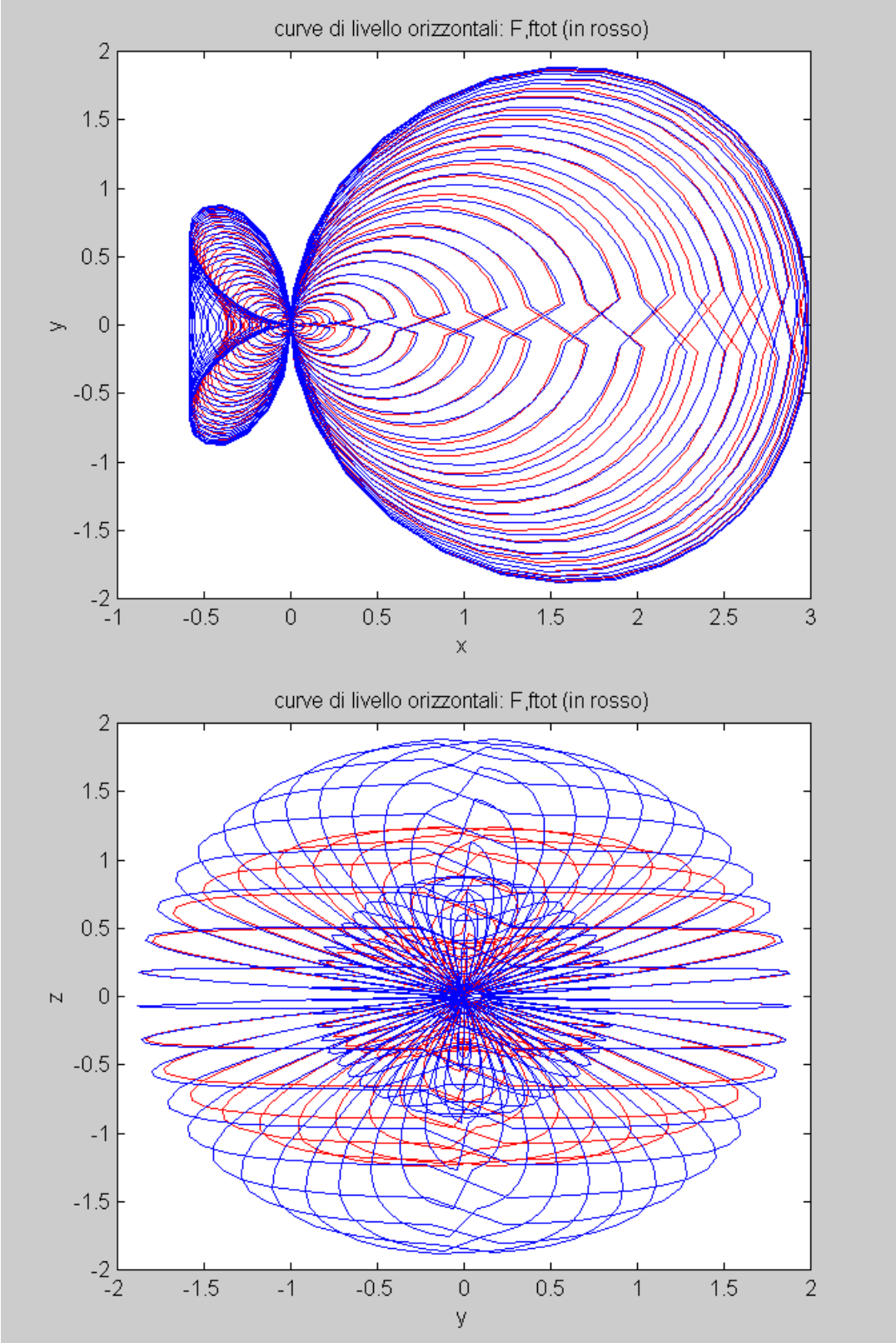
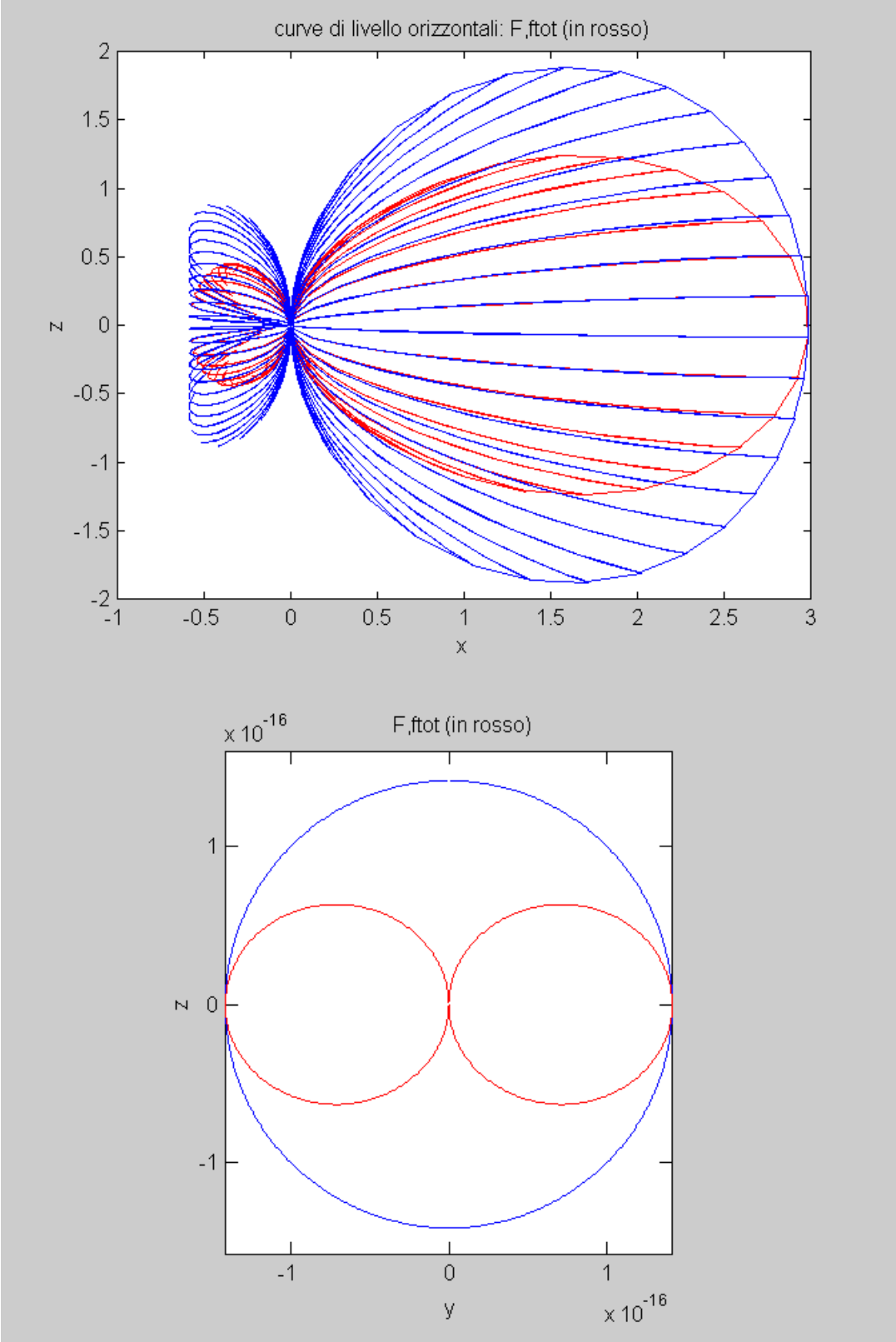
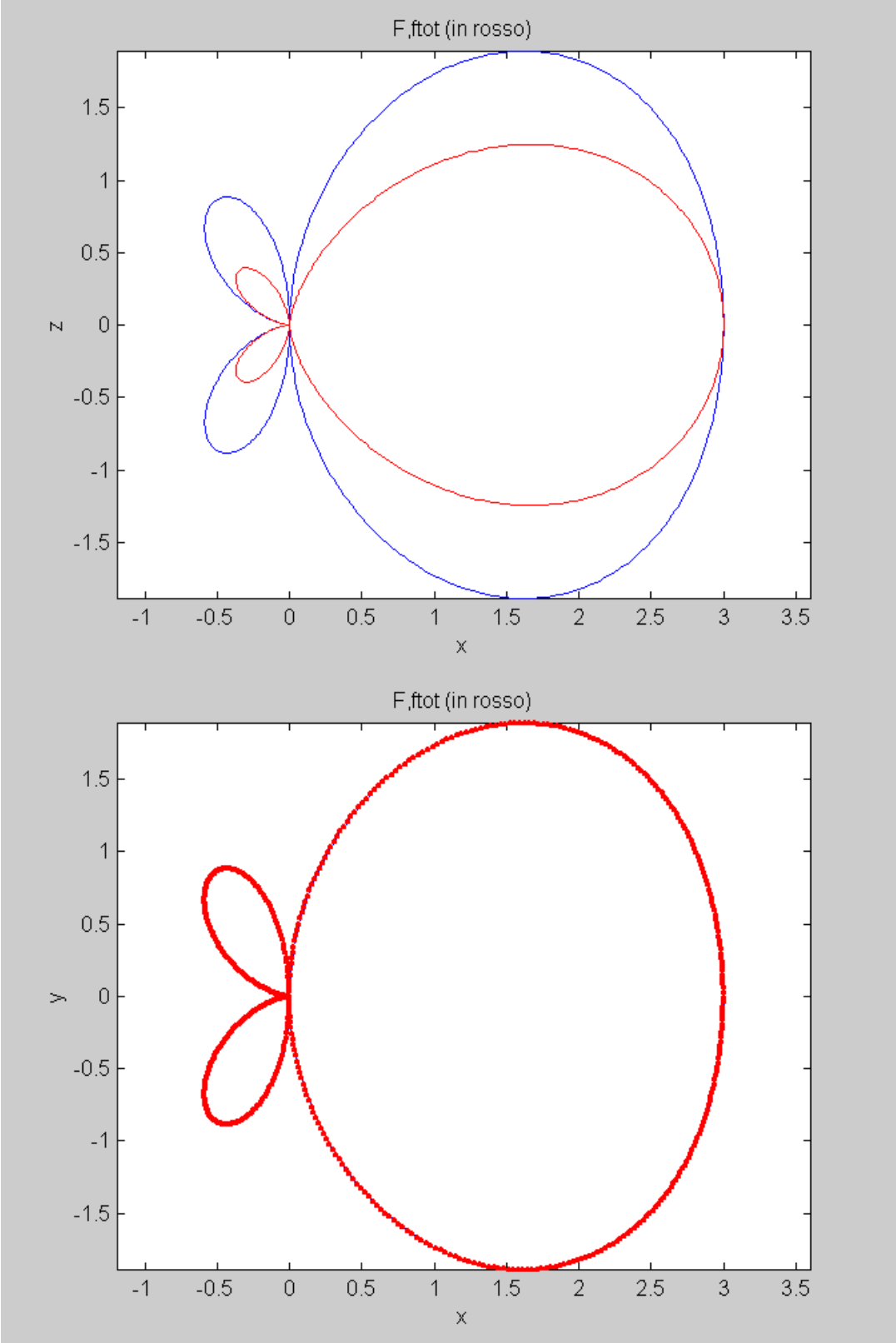


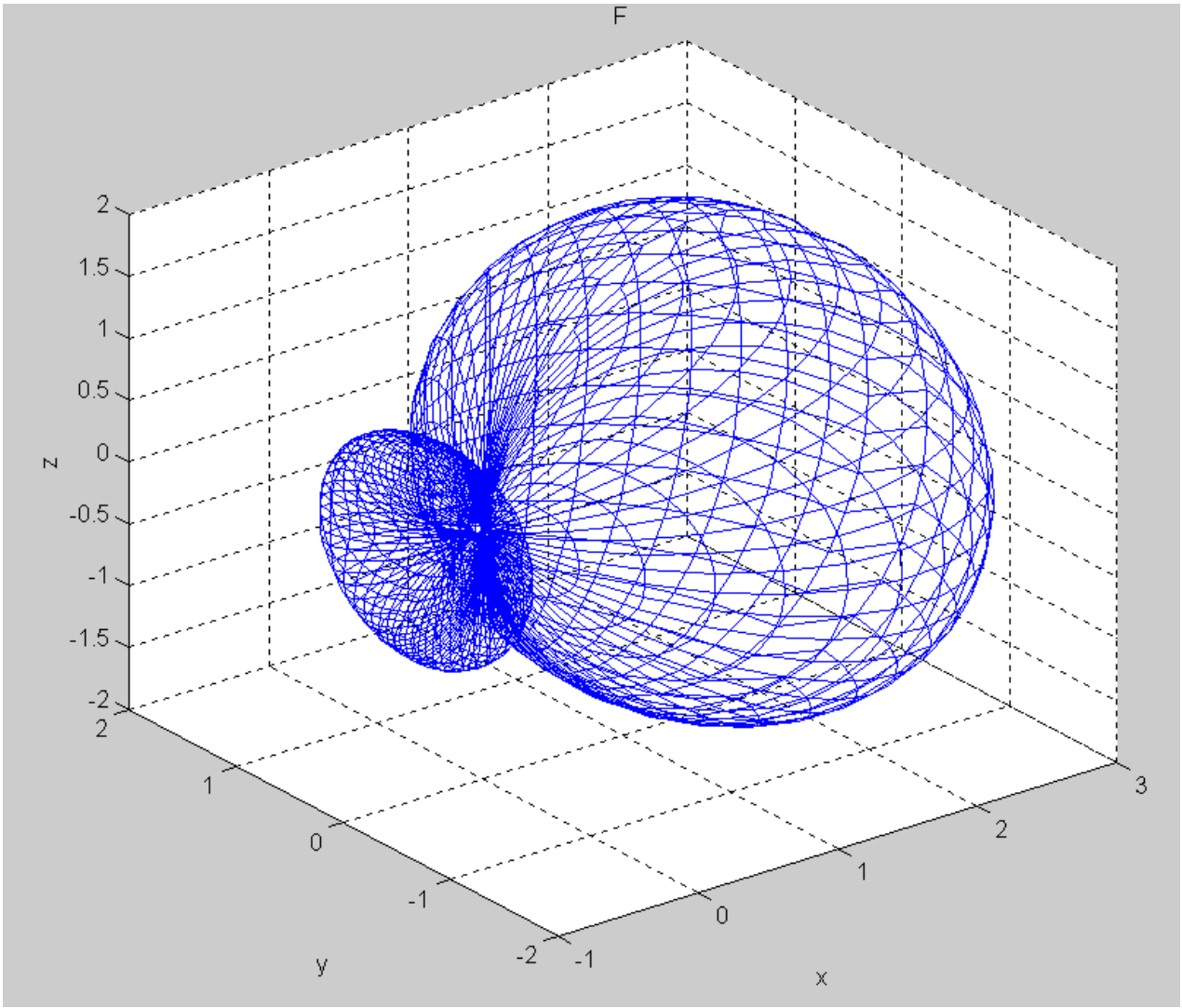
grafico: sin((N/2)*ko*d*(cos(Ψ)-1))/sin((1/2)*ko*d*(cos(Ψ)-1))
90
3
120
60
2
150
30
1
180
0
210
330
240
300
270
Ψ
curve di livello verticali: F,ftot (in rosso)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
y
-1
-0.5
0
0.5
1
1.5
2
2.5
3
x

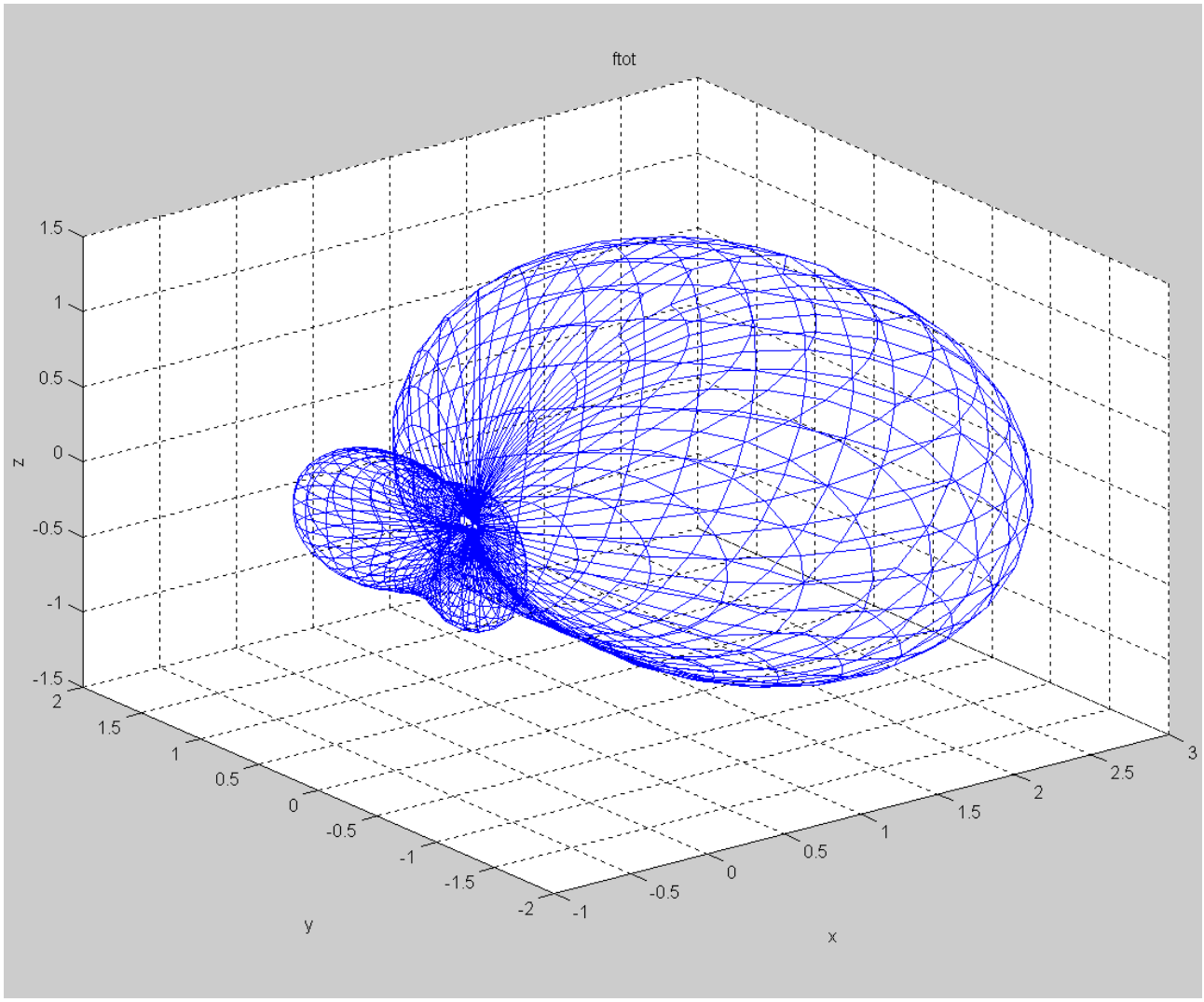

curve di livello verticali: F,ftot (in rosso)
z
y
curve di livello verticali: F,ftot (in rosso)
z
x

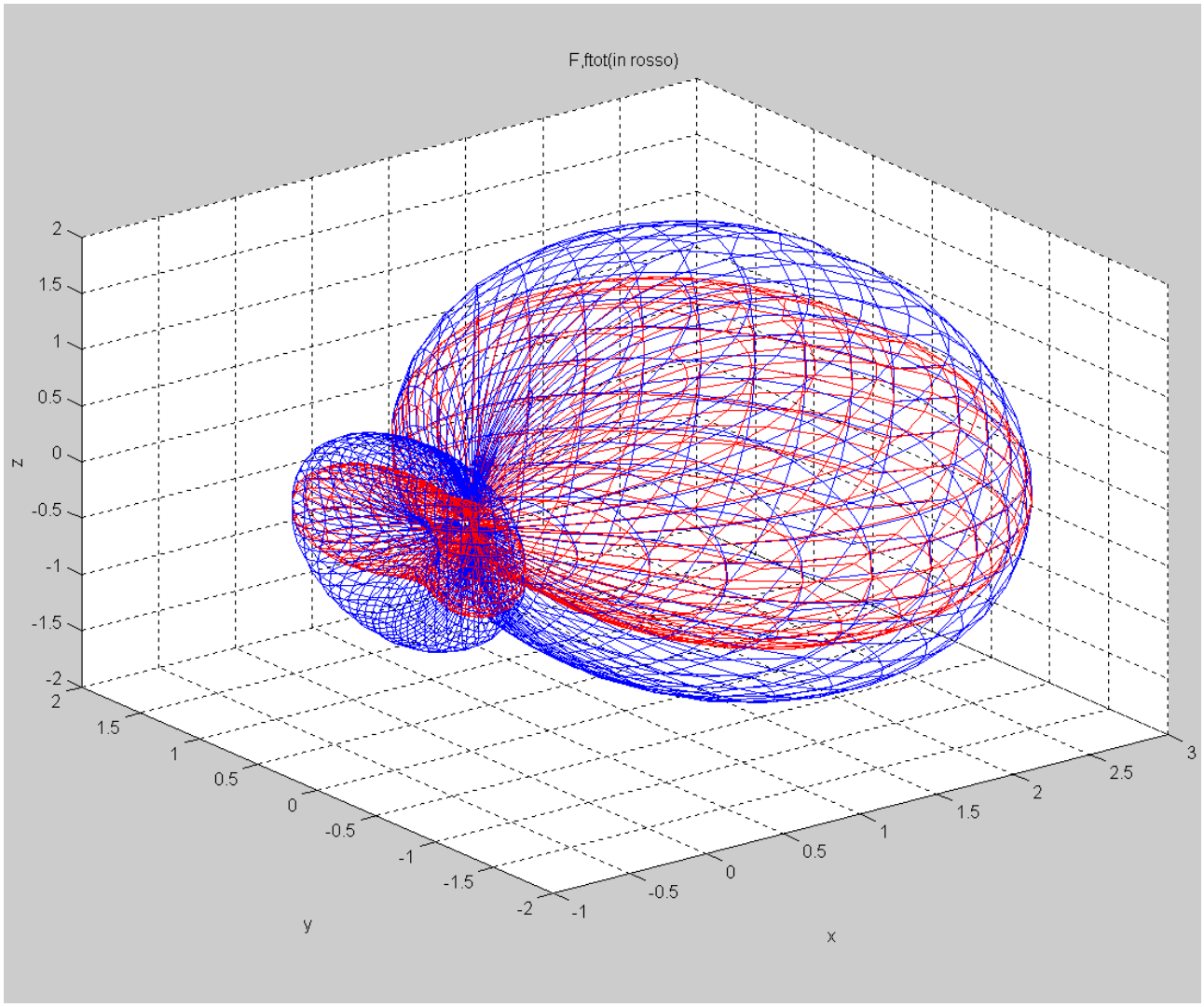

curve di livello orizzontali: F,ftot (in rosso)
y
x
curve di livello orizzontali: F,ftot (in rosso)
z
y


curve di livello orizzontali: F,ftot (in rosso)
z
x
F,ftot (in rosso)
x 10^-16
z
y
x 10^-16


F,ftot (in rosso)
z
x
F,ftot (in rosso)
y
x


F
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
z
2
1
0
-1
-2
y
-1
0
1
2
3
x


ftot
z
1.5
1
0.5
0
-0.5
-1
-1.5
y
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
x
-1
-0.5
0
0.5
1
1.5
2
2.5
3


F,ftot(in rosso)
z
y
x
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
3
2.5

collineare.m

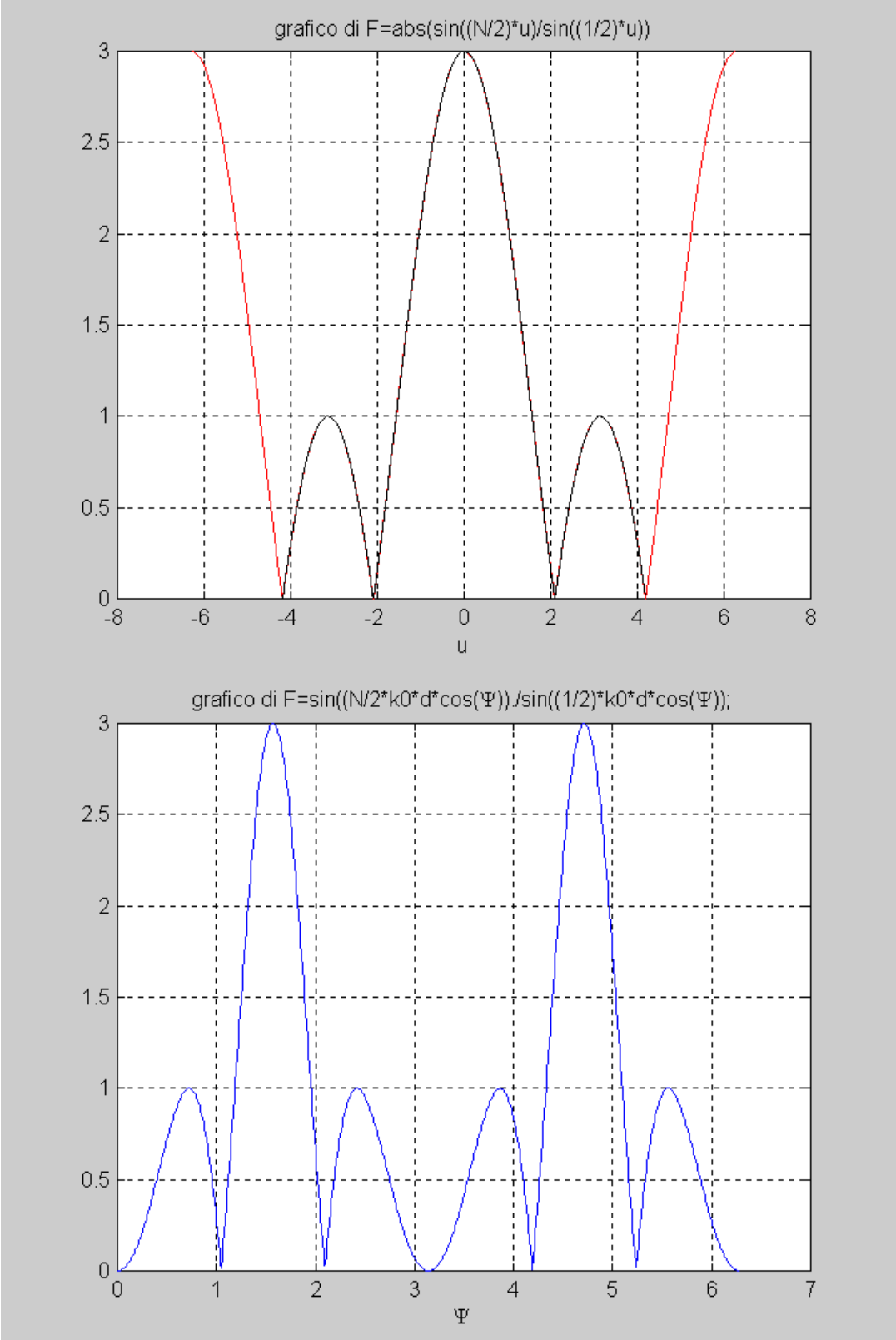
```
% disegno del grafico del fattore di schiera F
% e del corrispondente fattore di irradiazione totale ftot delle schiere
% collineari di antenne filiformi a lambda/2 distanti d =(2/3) di lambda

clear all
close all
lm=1;
N=3;
d=((N-1)/N)*lm;
kod=(2*pi/lm)*d;
u=-kod:0.01:kod;
u1=-2*pi:0.01:2*pi;
y=abs(sin((N/2)*u)./sin((1/2)*u));
y1=abs(sin((N/2)*u1)./sin((1/2)*u1));
plot(u1,y1,'r',u,y,'k')
title('grafico di F=abs(sin((N/2)*u)/sin((1/2)*u))')
xlabel('u')
zoom
grid
clear y
x=0:0.01:2*pi;
y=abs(sin((N/2)*kod*cos(x))./sin((1/2)*kod*cos(x)));
figure
plot(x,y)
title('grafico di F=sin((N/2*k0*d*cos(\Psi))./sin((1/2)*k0*d*cos(\Psi));')
xlabel('\Psi')
zoom
grid
clear x y

phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
             cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)))* ...
             (cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
phi=0:.09:2*pi; % è il TH del MATLAB
th=0:.09:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(th(i))~=0
```

```
         h=h+1;
         R1=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
             cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [x1(h),y1(h),z1(h)]=sph2cart(phi(j),pi/2-th(i),R1);
      end
   end
end
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0 & cos(th(i))~=0
         h=h+1;
         R1=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
             cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
         [x1(h),y1(h),z1(h)]=sph2cart(phi(j),pi/2-th(i),R1);
      end
   end
end

clear R TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      R(i)=sin((N/2)*kod*cos(TH(i)))/sin((1/2)*kod*cos(TH(i)));
```

```
   end
end

figure
polar(TH,R);
title('grafico: sin((N/2)*ko*d*cos(\Psi))/sin((1/2)*ko*d*cos(\Psi))')
figure
n=gcf;
plot(xx,yy)
xlabel('x')
ylabel('y')
axis equal
grid
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
axis equal
grid
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
axis equal
grid
%
%
%
figure
plot3(x1,y1,z1)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F');

figure
plot3(x,y,z)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('ftot');

figure
plot3(x1,y1,z1,x,y,z,'r')
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F,ftot (in rosso)');

clear x y R RR RRR RRRR xx xxx xxxx yy yyy yyyy zz zzz zzzz TH phi th

phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
              cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
```

```
            [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
        end
    end
end
clear R TH phi th
phi=0;       % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
    for i=1:length(th)
        if sin(th(i))~=0
            h=h+1;
            RRR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
                cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
            [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
        end
    end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
    for i=1:length(th)
        if sin(th(i))~=0
            h=h+1;
            RRRR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
                cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
            [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
        end
    end
end

clear R TH
figure(n)
hold on
plot(xx,yy,'.r')
hold off
xlabel('x')
ylabel('y')
title('F , fot (in rosso)');
axis equal
grid
figure(n+1)
hold on
plot(yyyy,zzzz,'r')
hold off
xlabel('y')
ylabel('z')
title('F , fot (in rosso)');
axis equal
grid
figure(n+2)
hold on
plot(xxx,zzz,'r')
hold off
xlabel('x')
ylabel('z')
title('F , fot (in rosso)');
axis equal
grid
```

Esecuzione del programma



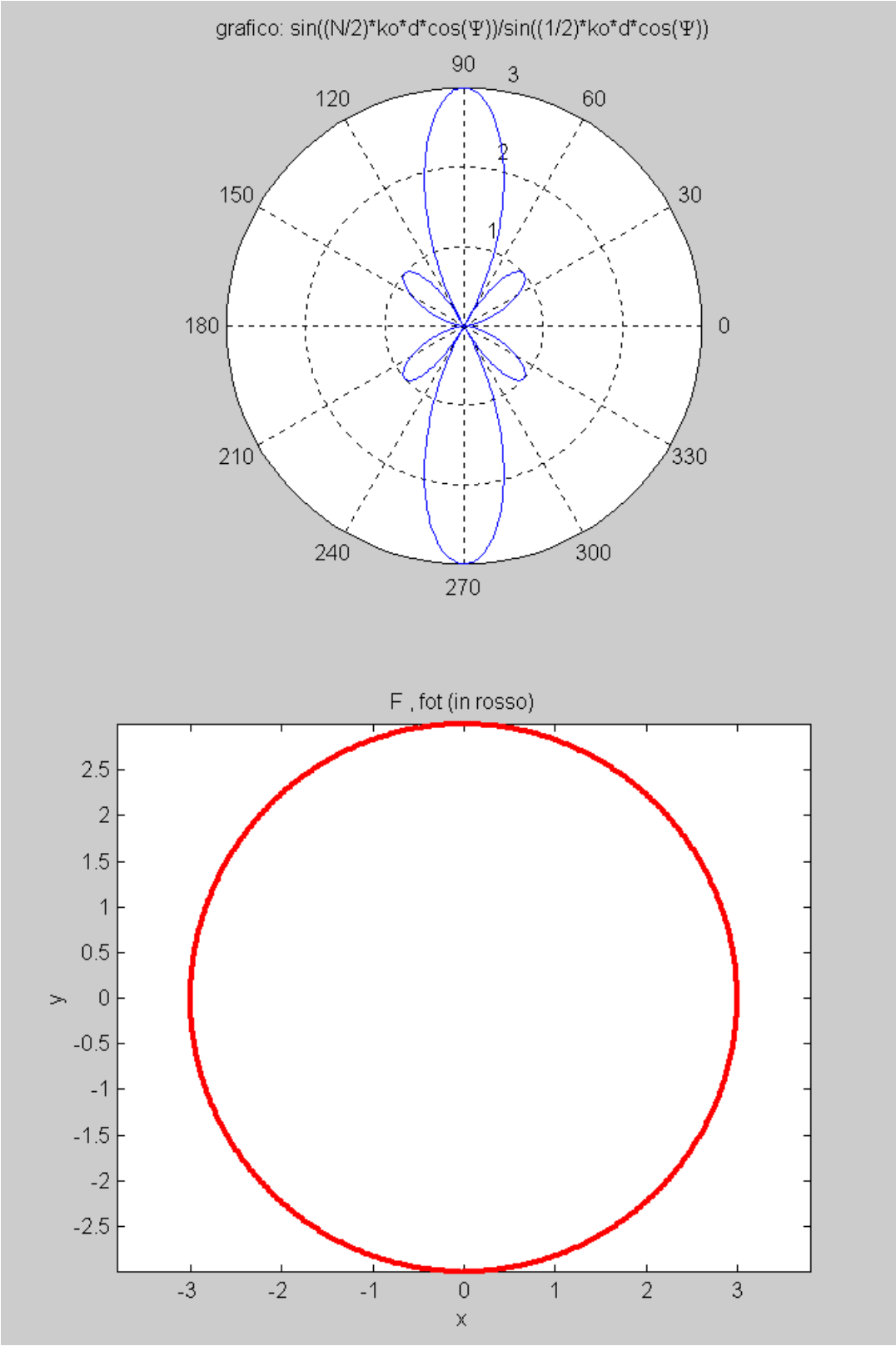
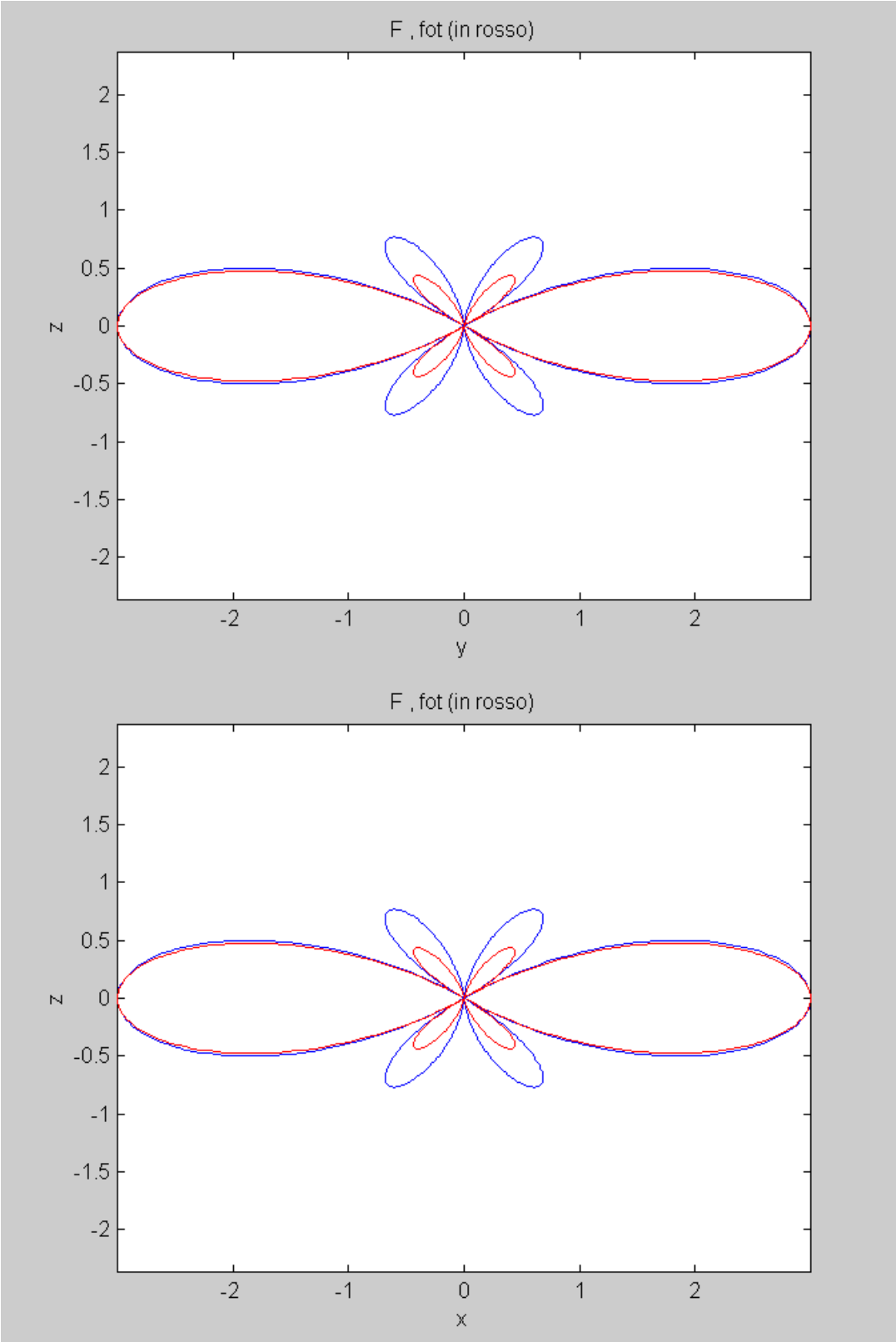
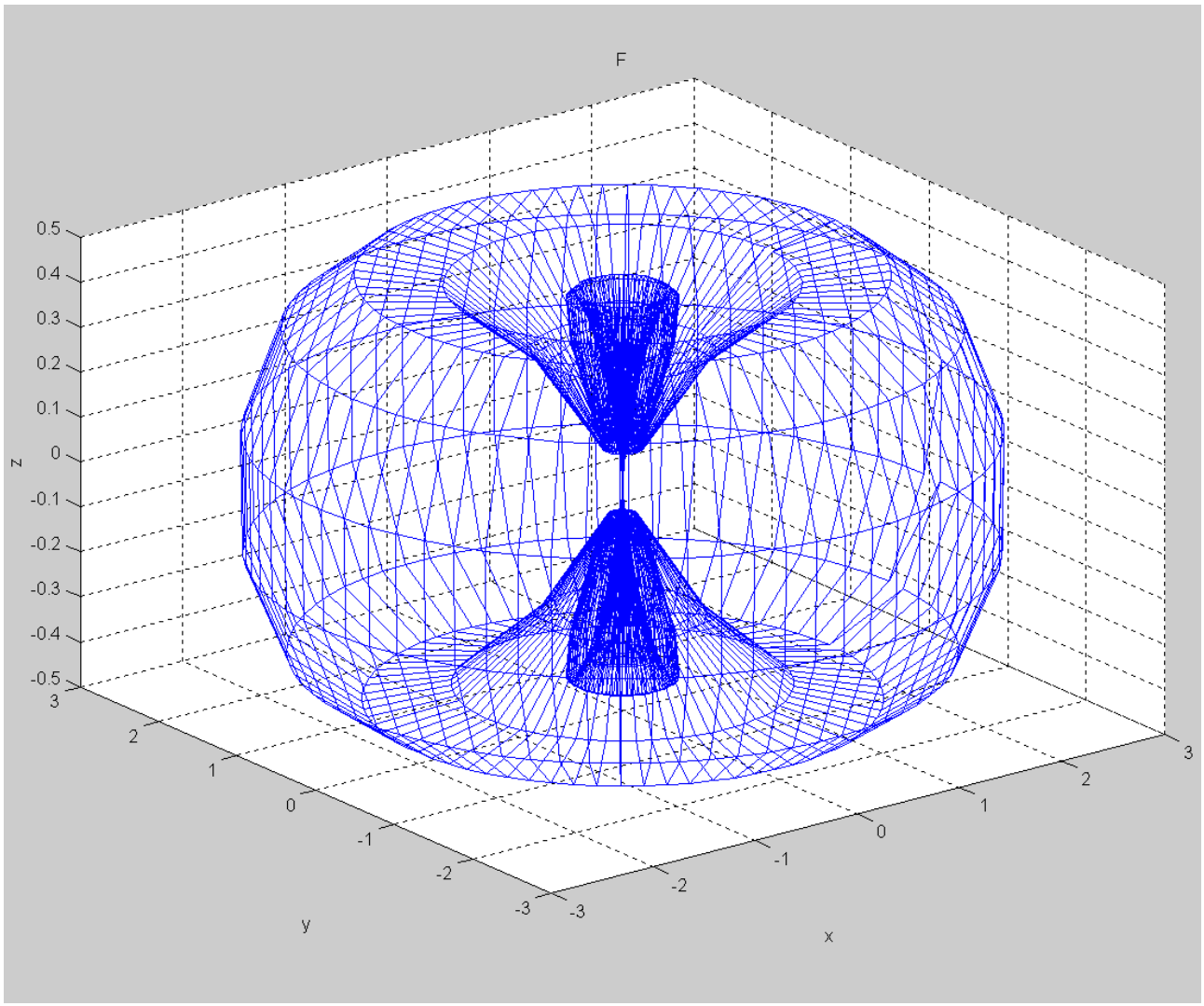
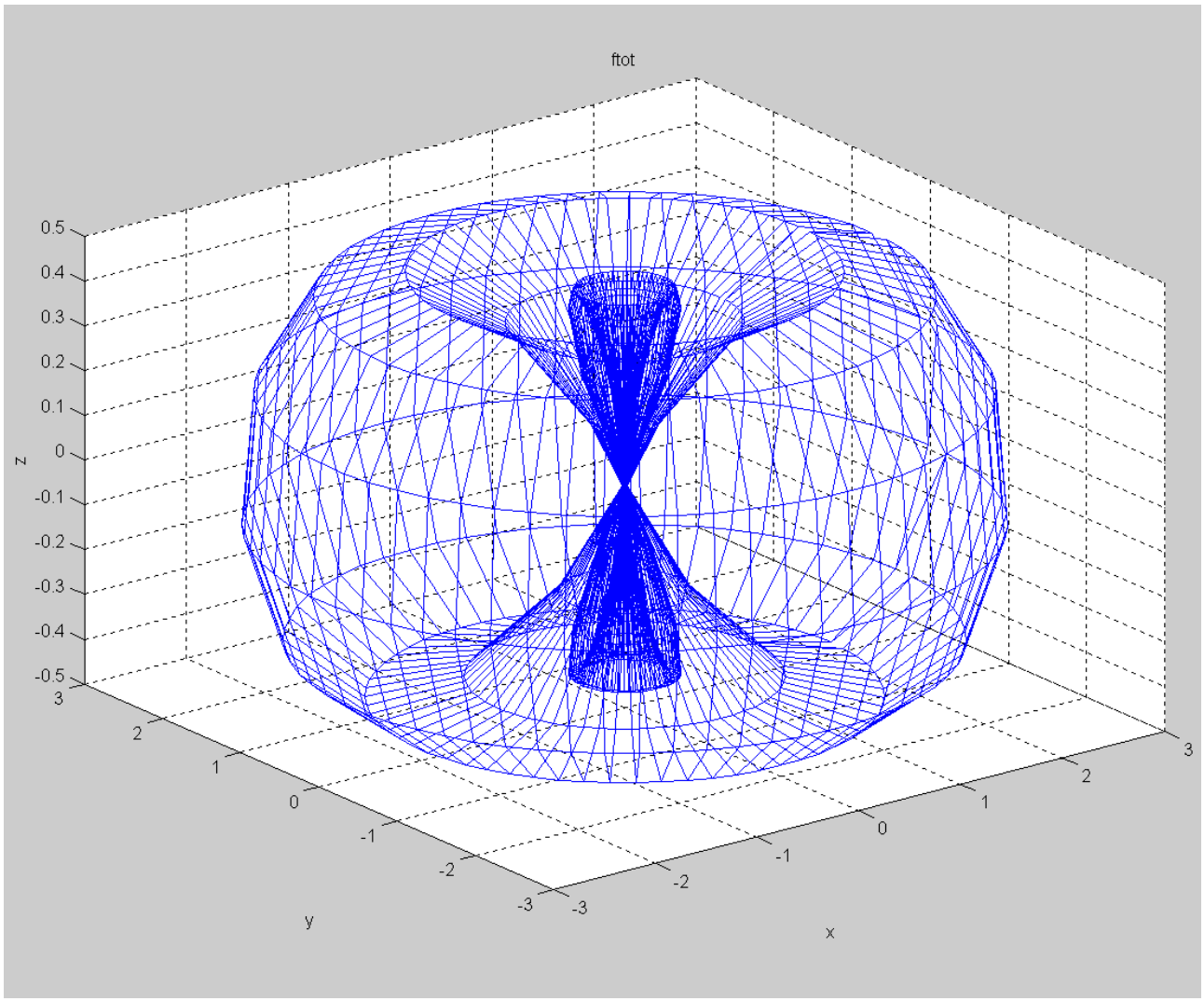
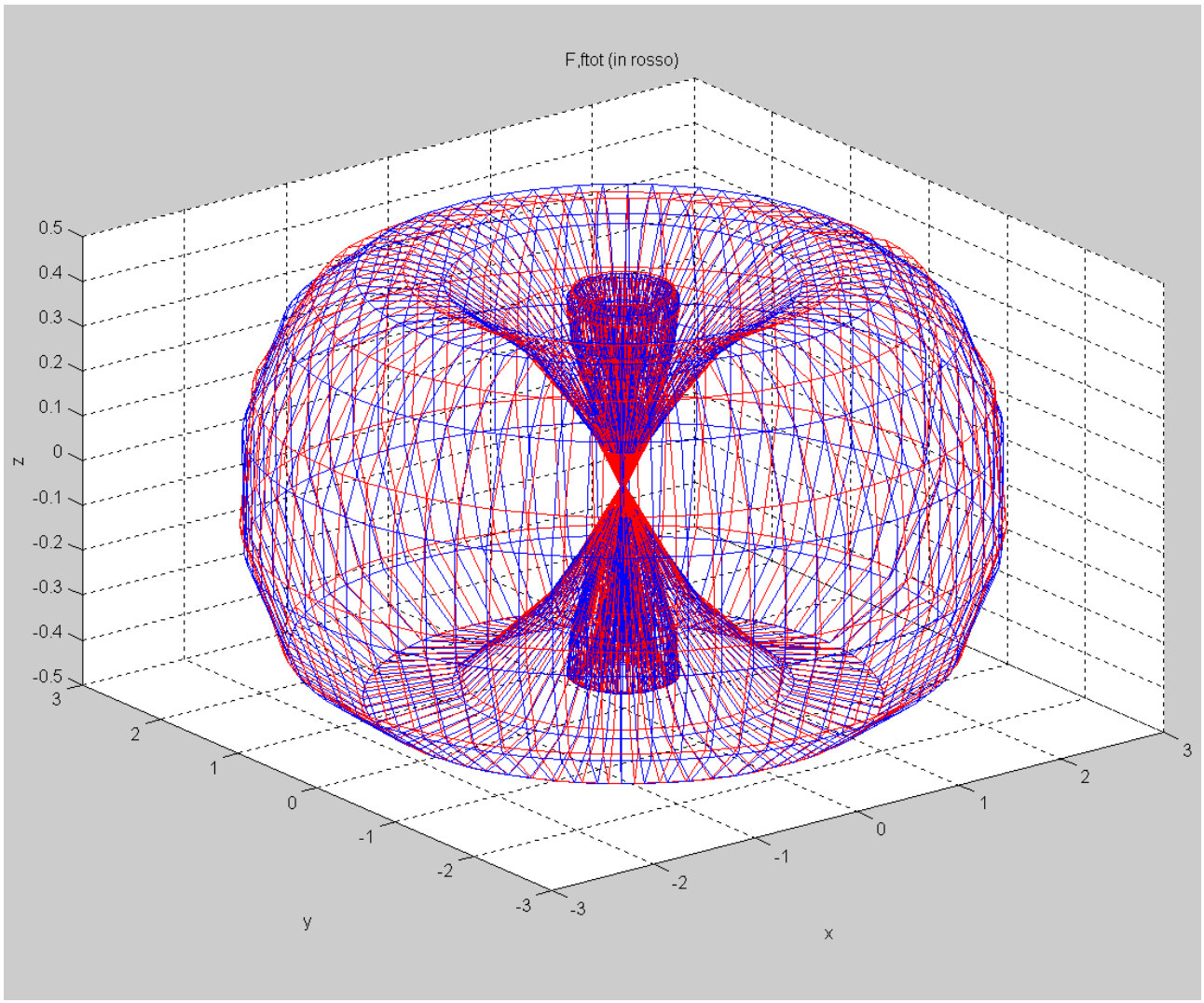


grafico: sin((N/2)*ko*d*cos(Ψ))/sin((1/2)*ko*d*cos(Ψ))
90
3
120
60
2
150
30
1
180
0
210
330
240
300
270
F , fot (in rosso)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
y
-3
-2
-1
0
1
2
3
x


F , fot (in rosso)
z
y
F , fot (in rosso)
z
x


F
z
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
y
3
2
1
0
-1
-2
-3
x
3
2
1
0
-1
-2
-3


ftot
z
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
y
3
2
1
0
-1
-2
-3
x
3
2
1
0
-1
-2
-3


F,ftot (in rosso)
z
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
y
3
2
1
0
-1
-2
-3
x
3
2
1
0
-1
-2
-3

planare.m

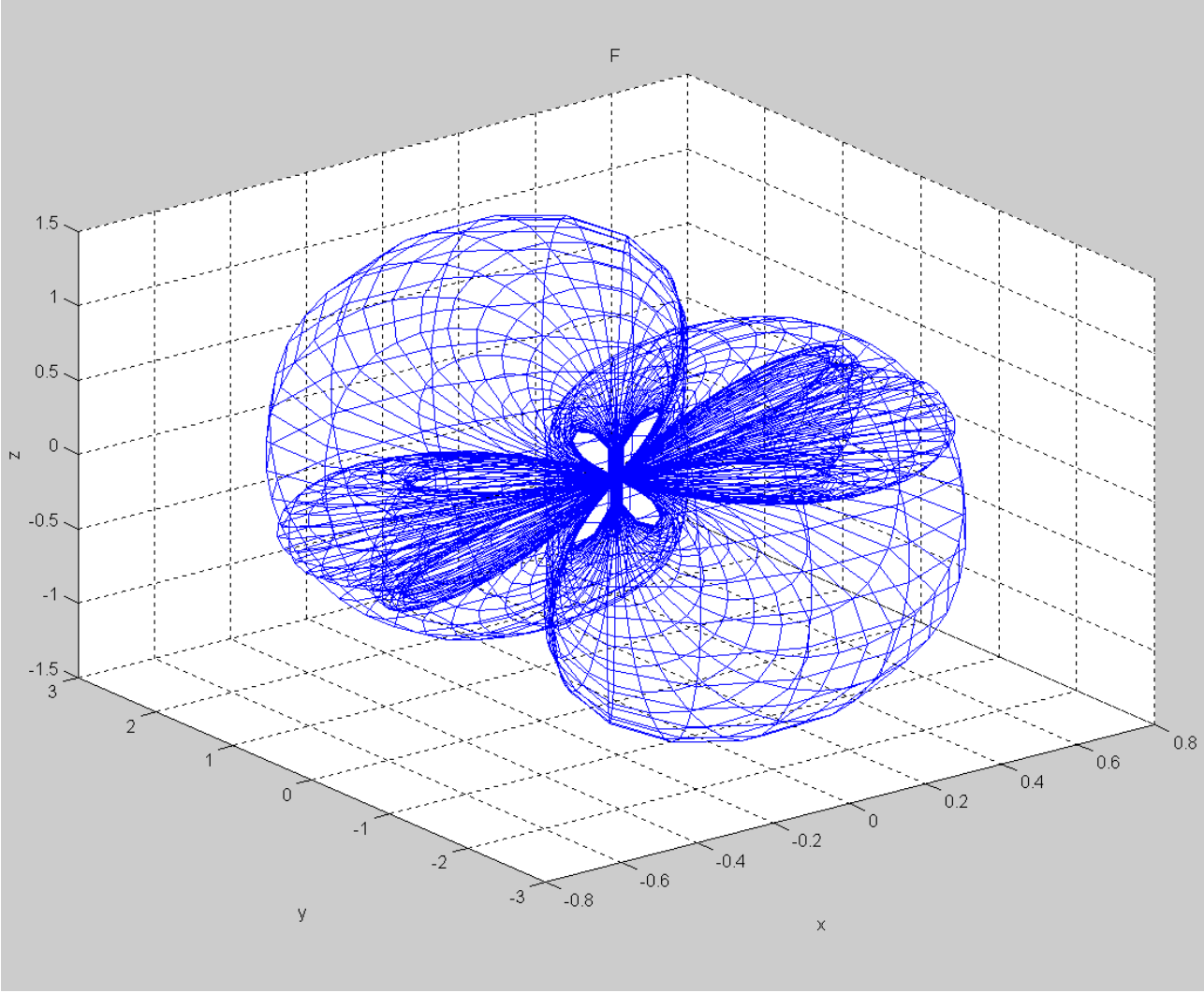
```
% disegno del grafico del fattore di schiera F
% e del corrispondente fattore di irradiazione totale ftot delle
% schiere planari di antenne filiformi a lambda/2 distanti d =(2/3) di lambda

clear all
close all
lm=1;
N=3;
d=((N-1)/N)*lm;
kod=(2*pi/lm)*d;
u=-kod:0.01:kod;
u1=-2*pi:0.01:2*pi;
y=abs(sin((N/2)*u)./sin((1/2)*u));
y1=abs(sin((N/2)*u1)./sin((1/2)*u1));
plot(u1,y1,'r',u,y,'k')
title('grafico di F=abs(sin((N/2)*u)/sin((1/2)*u))')
xlabel('u')
zoom
grid
clear y
x=0:0.01:2*pi;
y=abs(sin((N/2)*kod*cos(x))./sin((1/2)*kod*cos(x)));
figure
plot(x,y)
title('grafico di F=sin((N/2*k0*d*cos(\Psi))./sin((1/2)*k0*d*cos(\Psi));')
xlabel('\Psi')
zoom
grid
clear x y

phi=0:.1:2*pi; % è il TH del MATLAB
th=0:.1:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
             sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
for i=1:length(th)
   for j=1:length(phi)
      if sin(th(i))~=0
         h=h+1;
         R=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
             sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
         [x(h),y(h),z(h)]=sph2cart(phi(j),pi/2-th(i),R);
      end
   end
end
phi=0:.09:2*pi; % è il TH del MATLAB
th=0:.09:pi;  % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0 & cos(th(i))~=0
```

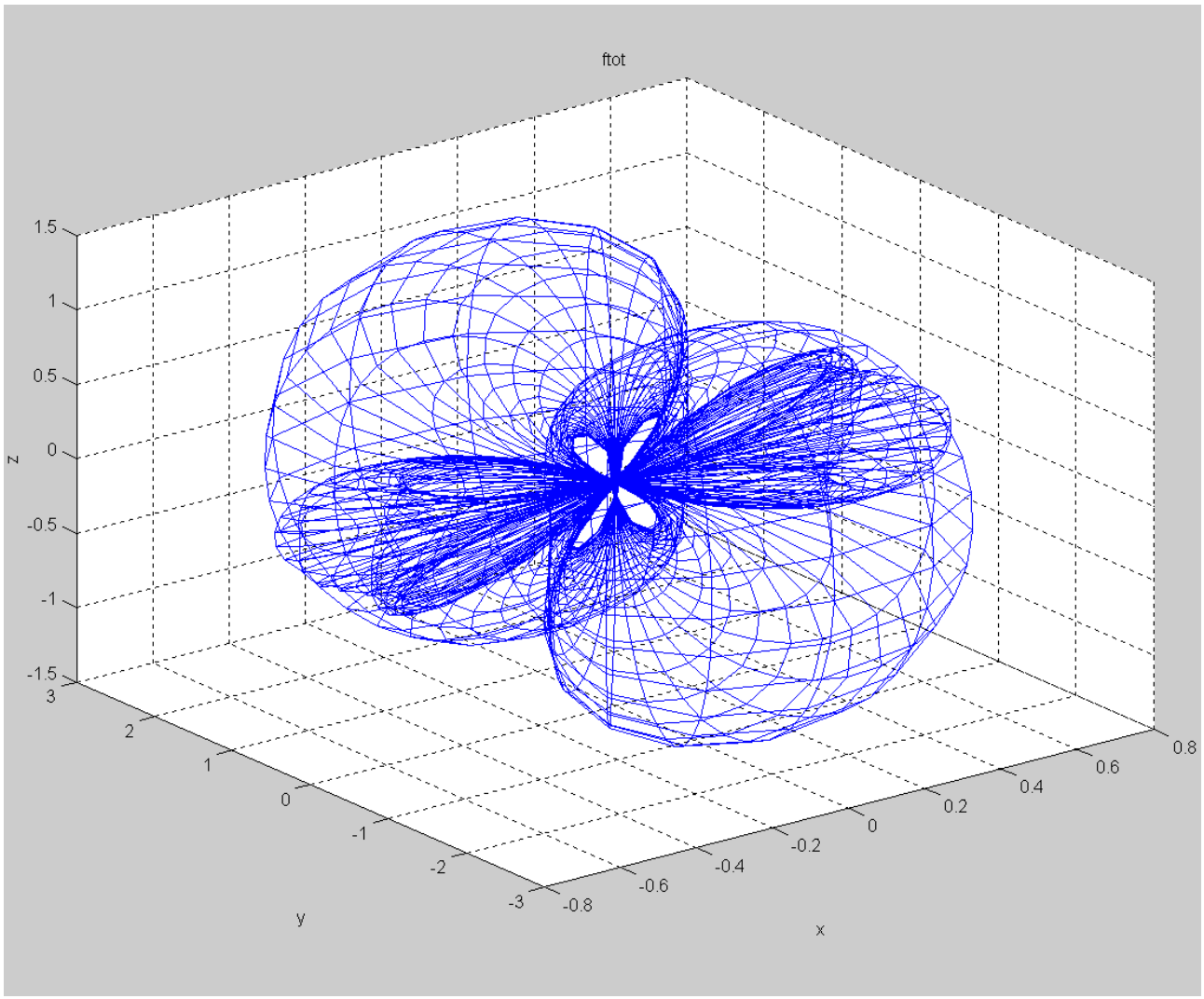
```
            h=h+1;
            R1=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
                sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
            [x1(h),y1(h),z1(h)]=sph2cart(phi(j),pi/2-th(i),R1);
         end
      end
   end
   for i=1:length(th)
      for j=1:length(phi)
         if sin(th(i))~=0 & cos(th(i))~=0
            h=h+1;
            R1=sin((N/2)*kod*sin(th(i))*cos(phi(j)))/sin((1/2)*kod*...
                sin(th(i))*cos(phi(j)))*(cos((pi/2)*cos(th(i)))/sin(th(i)));
            [x1(h),y1(h),z1(h)]=sph2cart(phi(j),pi/2-th(i),R1);
         end
      end
   end

clear R TH phi th RD
phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
      end
   end
end
clear R TH phi th
phi=0;      % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
      end
   end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;   % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RRRR=sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*cos(th(i)));
         [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
      end
   end
end

clear R TH
TH=0:0.01:2*pi;
for i=1:length(TH)
   if sin(TH(i))~=0
      R(i)=sin((N/2)*kod*cos(TH(i)))/sin((1/2)*kod*cos(TH(i)));
```

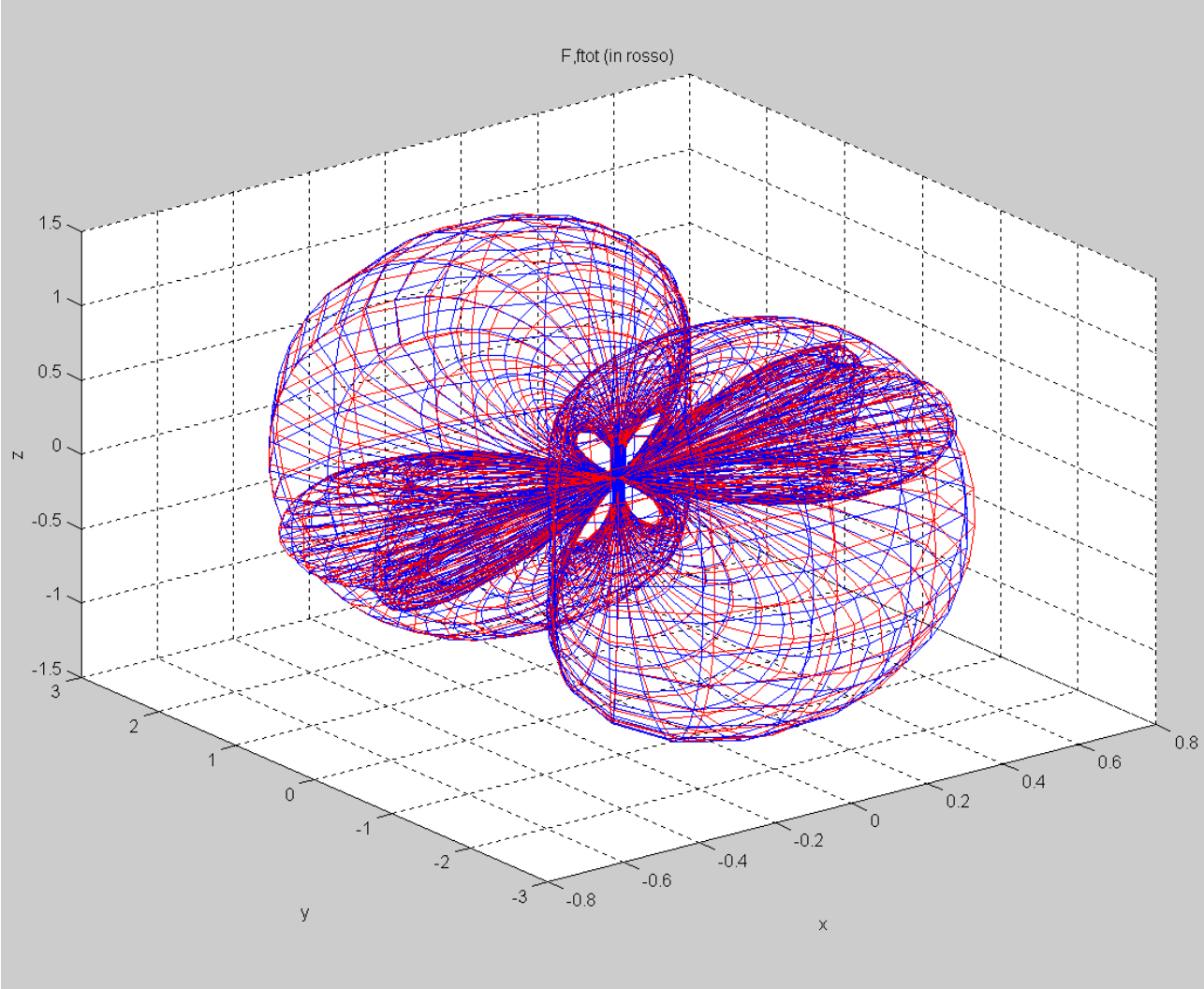
```
   end
end

figure
polar(TH,R);
title('grafico: sin((N/2)*ko*d*cos(\Psi))/sin((1/2)*ko*d*cos(\Psi))')
figure
n=gcf;
plot(xx,yy)
xlabel('x')
ylabel('y')
axis equal
grid
figure
plot(yyyy,zzzz')
xlabel('y')
ylabel('z')
axis equal
grid
figure
plot(xxx,zzz)
xlabel('x')
ylabel('z')
axis equal
grid
%
%
%
figure
plot3(x1,y1,z1)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F');

figure
plot3(x,y,z)
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('ftot');

figure
plot3(x1,y1,z1,x,y,z,'r')
grid
xlabel('x')
ylabel('y')
zlabel('z')
title('F,ftot (in rosso)');

clear x y R RR RRR RRRR xx xxx xxxx yy yyy yyyy zz zzz zzzz TH phi th

phi=-0.01:0.01:2*pi; % è il TH del MATLAB
th=pi/2;             % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
   for i=1:length(th)
      if sin(th(i))~=0
         h=h+1;
         RR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
             cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
```

```
            [xx(h),yy(h),zz(h)]=sph2cart(phi(j),pi/2-th(i),RR);
        end
    end
end
clear R TH phi th
phi=0;       % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
    for i=1:length(th)
        if sin(th(i))~=0
            h=h+1;
            RRR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
                cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
            [xxx(h),yyy(h),zzz(h)]=sph2cart(phi(j),pi/2-th(i),RRR);
        end
    end
end
clear R TH phi th
phi=pi/2; % è il TH del MATLAB
th=-0.01:0.01:2*pi;    % è pi/2-PHI del MATLAB
h=0;
for j=1:length(phi)
    for i=1:length(th)
        if sin(th(i))~=0
            h=h+1;
            RRRR=abs(sin((N/2)*kod*cos(th(i)))/sin((1/2)*kod*...
                cos(th(i)))*(cos((pi/2)*cos(th(i)))/sin(th(i))));
            [xxxx(h),yyyy(h),zzzz(h)]=sph2cart(phi(j),pi/2-th(i),RRRR);
        end
    end
end

clear R TH
figure(n)
hold on
plot(xx,yy,'.r')
hold off
xlabel('x')
ylabel('y')
title('F , fot (in rosso)');
axis equal
grid
figure(n+1)
hold on
plot(yyyy,zzzz,'r')
hold off
xlabel('y')
ylabel('z')
title('F , fot (in rosso)');
axis equal
grid
figure(n+2)
hold on
plot(xxx,zzz,'r')
hold off
xlabel('x')
ylabel('z')
title('F , fot (in rosso)');
axis equal
grid
```

Esecuzione del programma




ftot
1.5
1
0.5
0
-0.5
-1
-1.5
z
3
2
1
0
-1
-2
-3
y
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
x


F,ftot (in rosso)
z
1.5
1
0.5
0
-0.5
-1
-1.5
y
3
2
1
0
-1
-2
-3
x
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8