Convergence

P_1 close to ring:

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

```
clear all
close all
format long

R=10;
M=10;

rP=10;
phiP=pi/6;
zP=0.1;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
   0.006282242947179

>> circloopel_plot

Ex =

   3.227722117712293


Ey =

  -4.506377564176808


Ez =

   0.548066268007510


Er =

   5.543070342336026
```

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

```
clear all
close all
format long

R=10;
M=100;

rP=10;
phiP=pi/6;
zP=0.1;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
   0.006282242947179

>> circloopel_plot

Ex =

  -3.322267220677585


Ey =

   6.935259995671693


Ez =

   6.033320001230522


Er =

   7.689947379088682
```

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

```
clear all
close all
format long

R=10;
M=1000;

rP=10;
phiP=pi/6;
zP=0.1;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
```

Command Window

New to MATLAB? See resources for Getting Started.

```
   0.006282242947179

>> circloopel_plot

Ex =

   0.489228233498501


Ey =

   0.289567866343497


Ez =

  19.997566035457115


Er =

   0.568501375258486
```

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

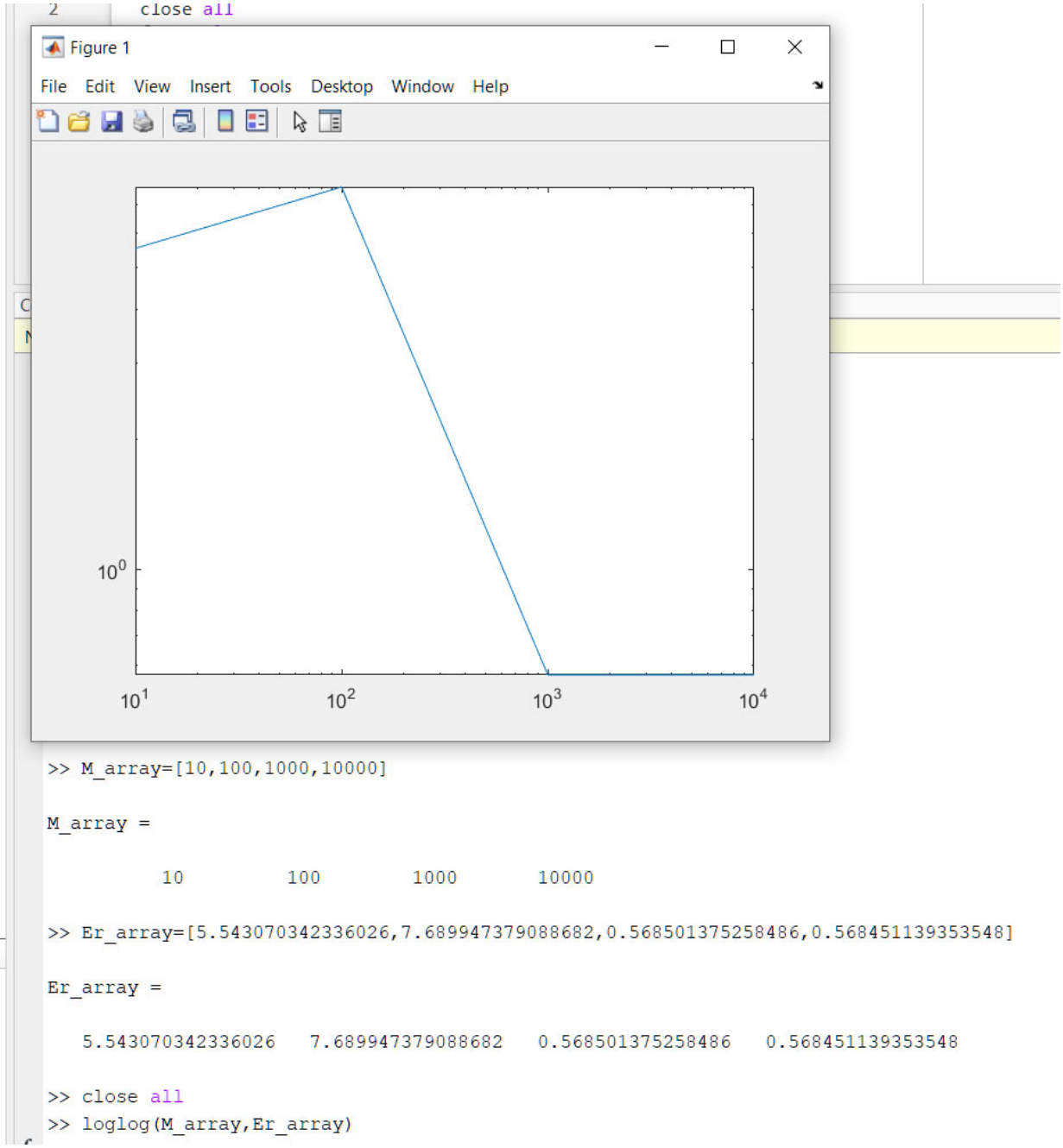
```
clear all
close all
format long

R=10;
M=10000;

rP=10;
phiP=pi/6;
zP=0.1;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
```

Command Window

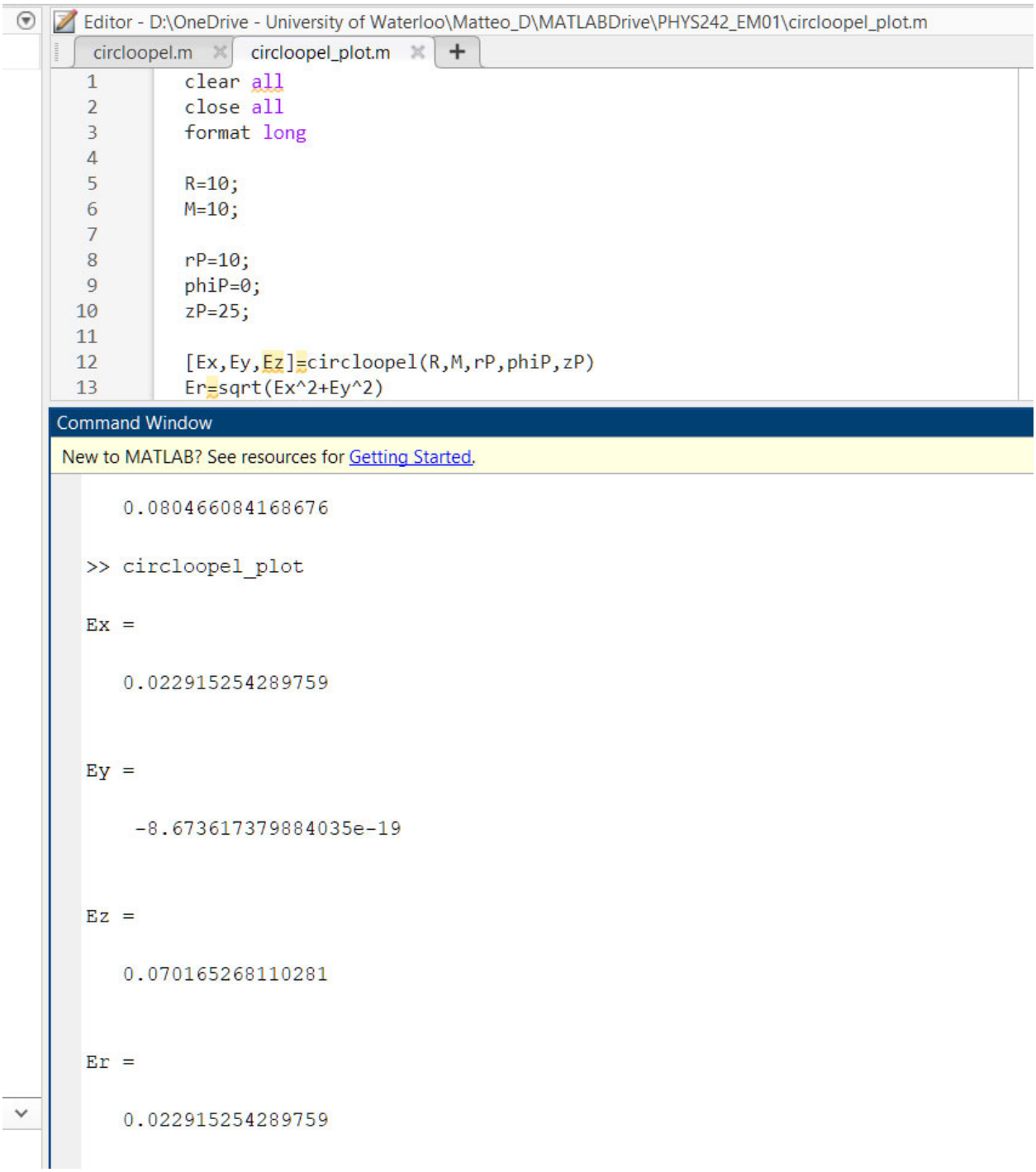
New to MATLAB? See resources for Getting Started.

```
   0.006282242947179

>> circloopel_plot

Ex =

   0.492293127491485


Ey =

   0.284225569674862


Ez =

  20.001296115891442


Er =

   0.568451139353548
```

convergence plot P_1:

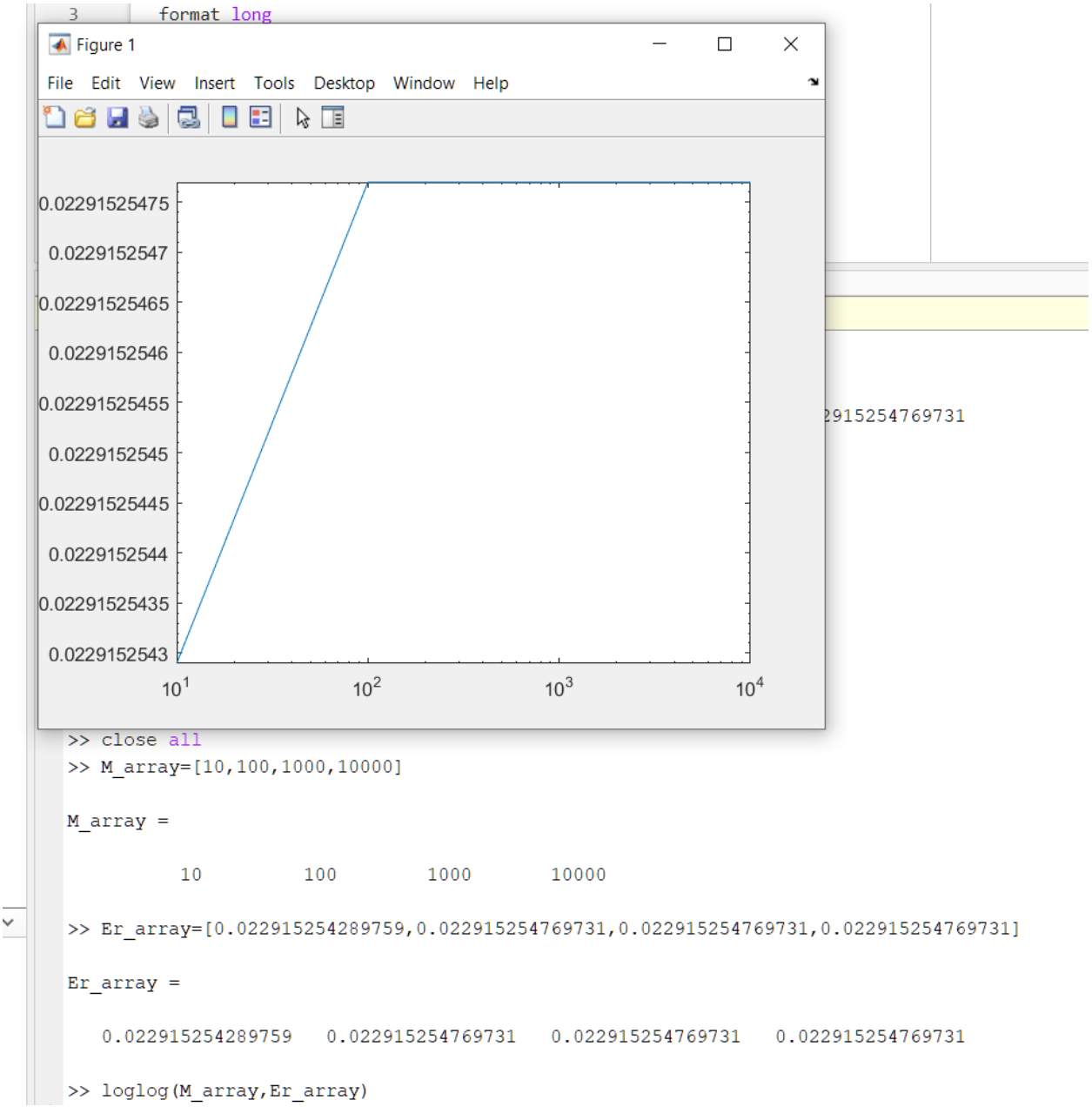


P_2 far way:



and similarly for M=100, 1000, 10000

convergence plot P_2:



Comparison with analytical result on z axis:

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

```
clear all
close all
format long

R=10;
M=100;

rP=0;
phiP=0;
zP=0;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
Ez_anal=2*pi*R*zP/(R^2+zP^2)^(3/2)
%
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> circloopel_plot

Ex =

    -9.454242944073599e-17


Ey =

    -1.951563910473908e-17


Ez =

     0


Er =

     9.653564696122859e-17


Ez_anal =

     0
```

Editor - D:\OneDrive - University of Waterloo\Matteo_D\MATLABDrive\PHYS242_EM01\circloopel_plot.m

circloopel.m | circloopel_plot.m

```
clear all
close all
format long

R=10;
M=100;

rP=0;
phiP=0;
zP=25;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
Ez_anal=2*pi*R*zP/(R^2+zP^2)^(3/2)
%
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> circloopel_plot

Ex =

    -5.095750210681871e-18


Ey =

    -3.950561665994057e-18


Ez =

   0.080466084168676


Er =

     6.447759896777024e-18


Ez_anal =

   0.080466084168676
```

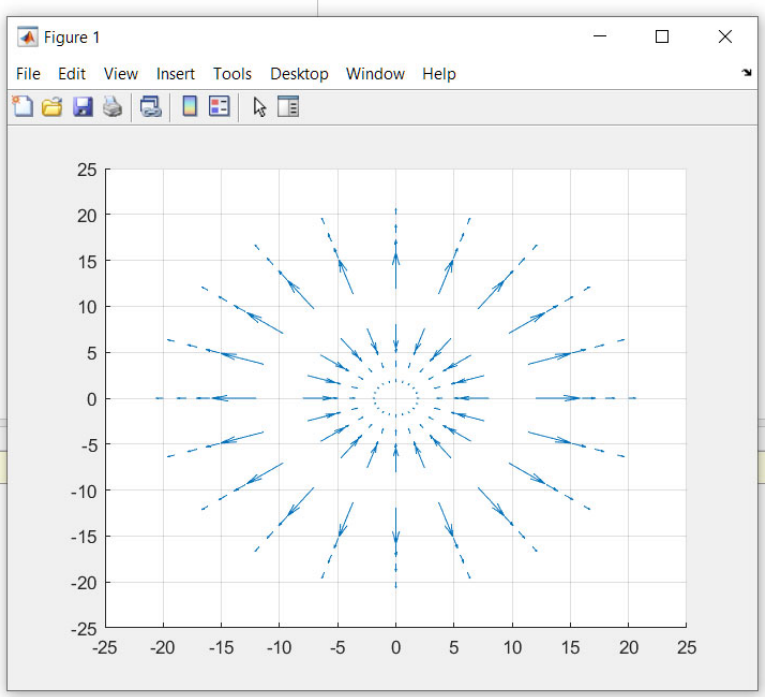
Plots

```
%

s=0.05;

rP=0:2:20;
phiP=(0:s:1)*2*pi;
zP=0;

[RP,PHIP,ZP]=meshgrid(rP,phiP,zP);
XP=RP.*cos(PHIP);
YP=RP.*sin(PHIP);

[Ex,Ey,Ez]=circloopel(R,M,RP,PHIP,ZP);

% scale=0.75;
% quiver3(XP,YP,ZP,Ex,Ey,Ez,scale)
quiver3(XP,YP,ZP,Ex,Ey,Ez)
view(0, 90)
%
```

d Window

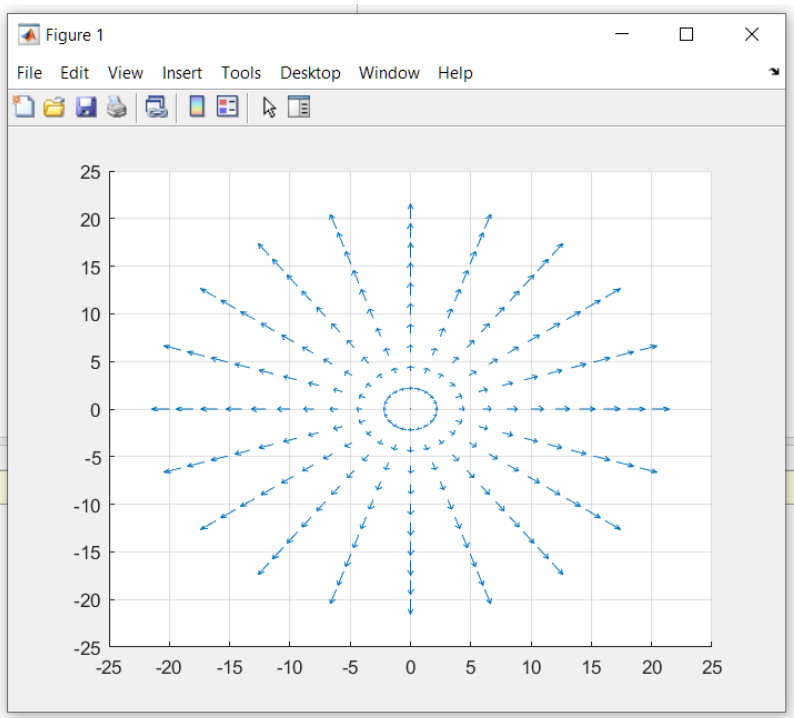
MATLAB? See resources for Getting Started.

```
).080466084168676


  6.447759896777024e-18
```



ring “visible” where arrows are missing
arrows point away from ring
arrows are symmetric with respect to z axis

```
%

s=0.05;

rP=0:2:20;
phiP=(0:s:1)*2*pi;
zP=25;

[RP,PHIP,ZP]=meshgrid(rP,phiP,zP);
XP=RP.*cos(PHIP);
YP=RP.*sin(PHIP);

[Ex,Ey,Ez]=circloopel(R,M,RP,PHIP,ZP);

% scale=0.75;
% quiver3(XP,YP,ZP,Ex,Ey,Ez,scale)
quiver3(XP,YP,ZP,Ex,Ey,Ez)
view(0, 90)
%
```



indow

LAB? See resources for Getting Started.

30466084168676

.447759896777024e-18

CODE:

```
function [Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
% ,phiQ_vec
% Ke=\lambda/(4*pi*epsilon0)=1;

% R=10;

% M=100;
Delta_phi=2*pi/M;
Delta_ell=R*Delta_phi;

% rP=0;
% phiP=0;
% zP=0.1;

m=0;
phiQ=0;
DeltaEx=0;
Ex=0;
DeltaEy=0;
Ey=0;
DeltaEz=0;
Ez=0;

for m=1:M

    phiQ=-Delta_phi+m*Delta_phi;
    % phiQ_vec(m)=phiQ;

    DeltaEx=Delta_ell*(rP.*cos(phiP)-R*cos(phiQ))./(rP.^2+R^2-2*R*rP.*cos(phiQ-
phiP)+zP.^2).^(3/2);
    Ex=Ex+DeltaEx;

    DeltaEy=Delta_ell*(rP.*sin(phiP)-R*sin(phiQ))./(rP.^2+R^2-2*R*rP.*cos(phiQ-
phiP)+zP.^2).^(3/2);
    Ey=Ey+DeltaEy;

    DeltaEz=Delta_ell*zP./(rP.^2+R^2-2*R*rP.*cos(phiQ-phiP)+zP.^2).^(3/2);
    Ez=Ez+DeltaEz;

end

end
% DDD
```

```
clear all
close all
format long

R=10;
M=100;
```

```
rP=0;
phiP=0;
zP=25;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
Ez_anal=2*pi*R*zP/(R^2+zP^2)^(3/2)
%

s=0.05;
rP=0:2:20;
phiP=(0:s:1)*2*pi;
zP=25;

[RP,PHIP,ZP]=meshgrid(rP,phiP,zP);
XP=RP.*cos(PHIP);
YP=RP.*sin(PHIP);

[Ex,Ey,Ez]=circloopel(R,M,RP,PHIP,ZP);

% scale=0.75;
% quiver3(XP,YP,ZP,Ex,Ey,Ez,scale)
quiver3(XP,YP,ZP,Ex,Ey,Ez)
view(0,90)
%
% DDD
```

OLD CODE:

```
clear all
close all
format long

R=10;
M=10; % 20

rP=15;
phiP=pi/6;
zP=20;

[Ex,Ey,Ez]=circloopel(R,M,rP,phiP,zP)
Er=sqrt(Ex^2+Ey^2)
Ez_anal=2*pi*R*zP/(R^2+zP^2)^(3/2)
%

% rP=0;
% phiP=pi;
% zP=20; % 9; 20; 0

s=0.05; % 0.01

% rP=(0:s:1)*20; % 15
rP=0:2:20;
% phiP=[0:2*pi/s:2*pi];
phiP=(0:s:1)*2*pi;
zP=0; % 1; 25

% [XP,YP,ZP]=meshgrid(rP.*cos(phiP),rP.*sin(phiP),zP);
[RP,PHIP,ZP]=meshgrid(rP,phiP,zP);
XP=RP.*cos(PHIP);
YP=RP.*sin(PHIP);

% [Bx,By,Bz] = circloopmag(R,M,rP,phiP,zP);
[Ex,Ey,Ez]=circloopel(R,M,RP,PHIP,ZP);
% [BX,BY,BZ]=meshgrid(Bx,By,Bz);
% Br=sqrt(Bx.^2+By.^2);
% Bphi=zeros(1,length(Br));

% scale=0.75;
% quiver3(XP,YP,ZP,Ex,Ey,Ez,scale)
% quiver3(XP,YP,ZP,Bx',By',Bz')
quiver3(XP,YP,ZP,Ex,Ey,Ez)
% view(0, 90)
%
```