Companion software for "Volker Ziemann, *Hands-on Accelerator physics using MATLAB, CRCPress, 2019*" (https://www.crcpress.com/9781138589940)

Super-conducting dipole defined by intersecting circles (Section 4.4.2)

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Important: this example requires the PDE toolbox!

In Section 4.4.1 we found that a current distribution that has the form of two intersecting circles produces a dupole field in the inside region. We therefore define two circles `C1` and `C2`, displaced horizontally by ± 5 cm and having a radius of 0.5 m, enclosed in a square `World` with 2 m to each side and defined as a polygon.

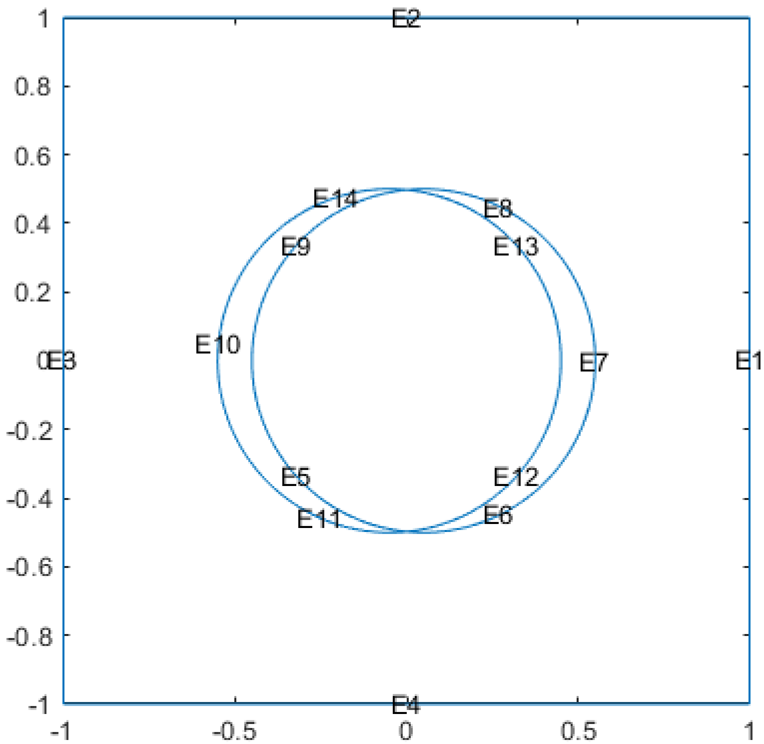
```
clear all; close all
C1=[1;0.05;0;0.5;zeros(6,1)];
C2=[1;-0.05;0;0.5;zeros(6,1)];
World=[2;4; -1;1;1;-1;-1;-1;1;1];
```

Then we assemble the geometry g, create the model and add the geometry to it.

```
gd=[World,C1,C2];  % assemble geometry
ns=char('World','C1','C2')';  % names of the regions
sf='World+(C1-C2)';
g=decsg(gd,sf,ns);
model=createpde(1);
geometryFromEdges(model,g);
```

At this point, we display the EdgeLabels, which allows us to set u $= A_z$ on the outer limits of the World to zero.

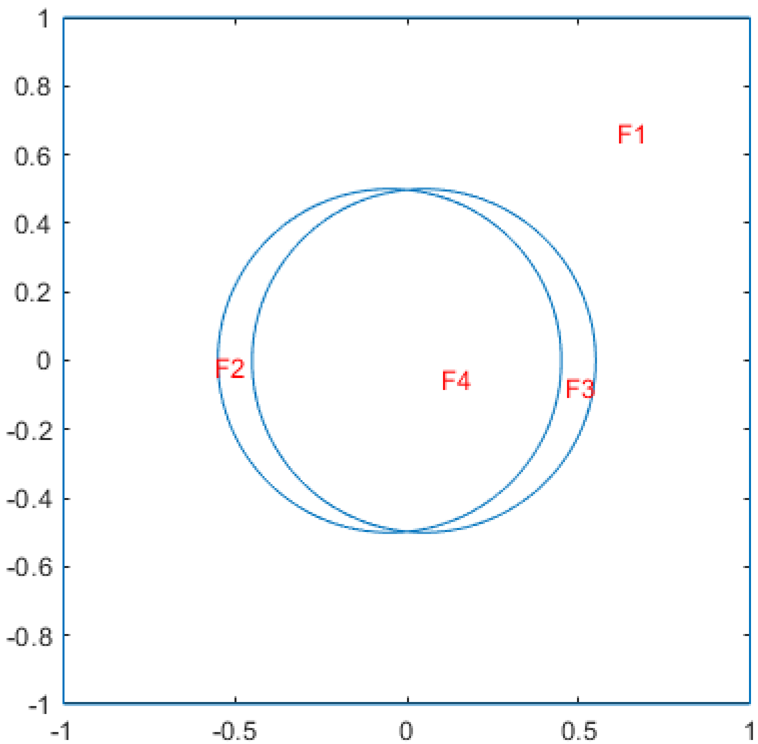
```
pdegplot(model,'EdgeLabels','on'); axis square;
```




```
applyBoundaryCondition(model,'Edge',[1:4],'u',0);
```

The material is specified to have permeability $\mu_r = 1$ everywhere and the current correpsonding to f=100 is approximately 80×10^6 A/m^2.

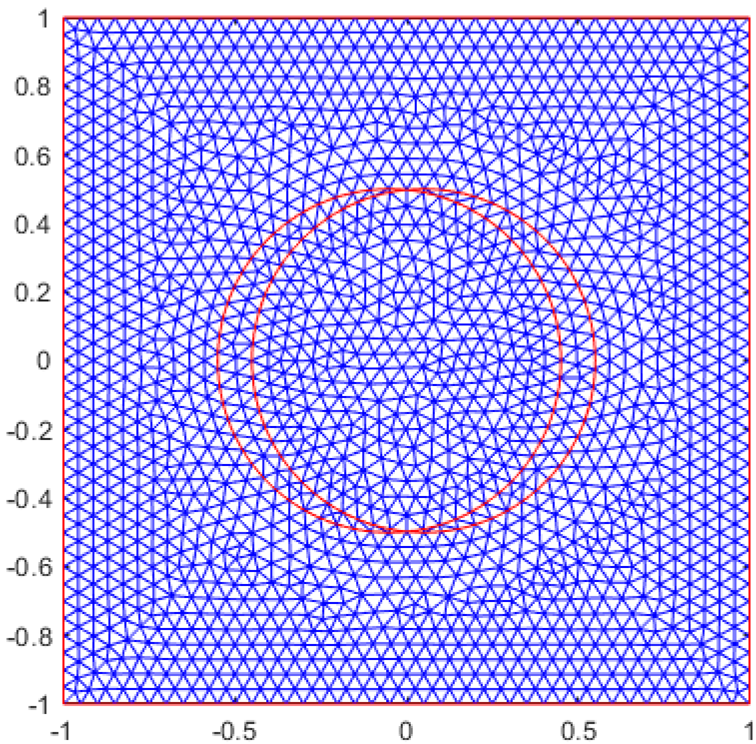
```
figure;
pdegplot(model,'SubDomainLabels','on'); axis square;
```




```
specifyCoefficients(model,'m',0,'d',0,'c',1,'a',0,'f',0,'Face',[1,4]);
specifyCoefficients(model,'m',0,'d',0,'c',1,'a',0,'f',100,'Face',2);
specifyCoefficients(model,'m',0,'d',0,'c',1,'a',0,'f',-100,'Face',3);
```

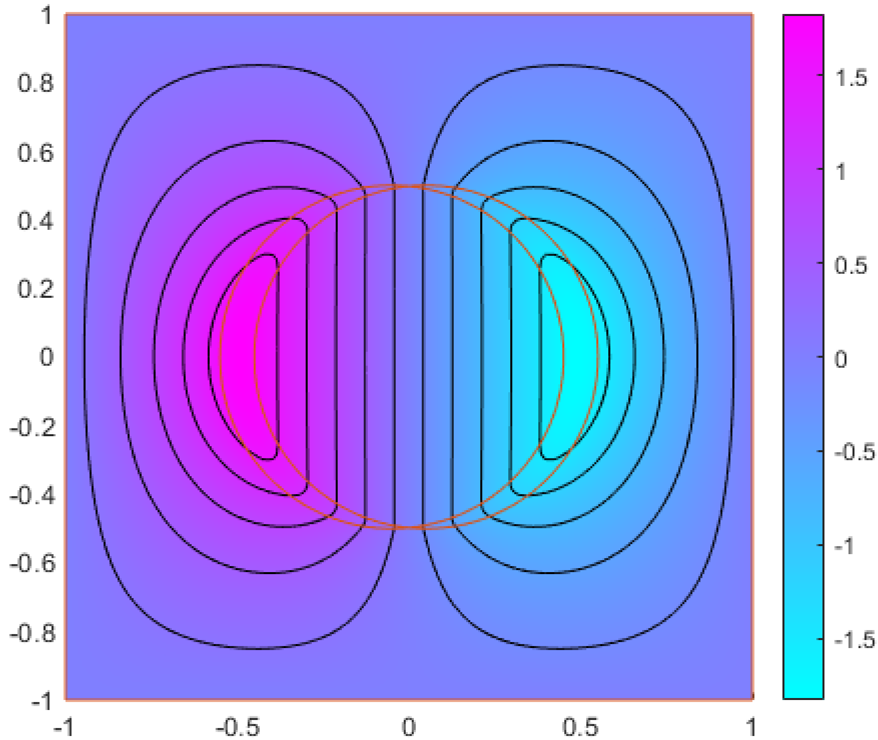
In the next step we mesh the geometry and siplay the mesh.

```
figure;
generateMesh(model,'Hmax',0.05);
pdemesh(model); axis square;
```



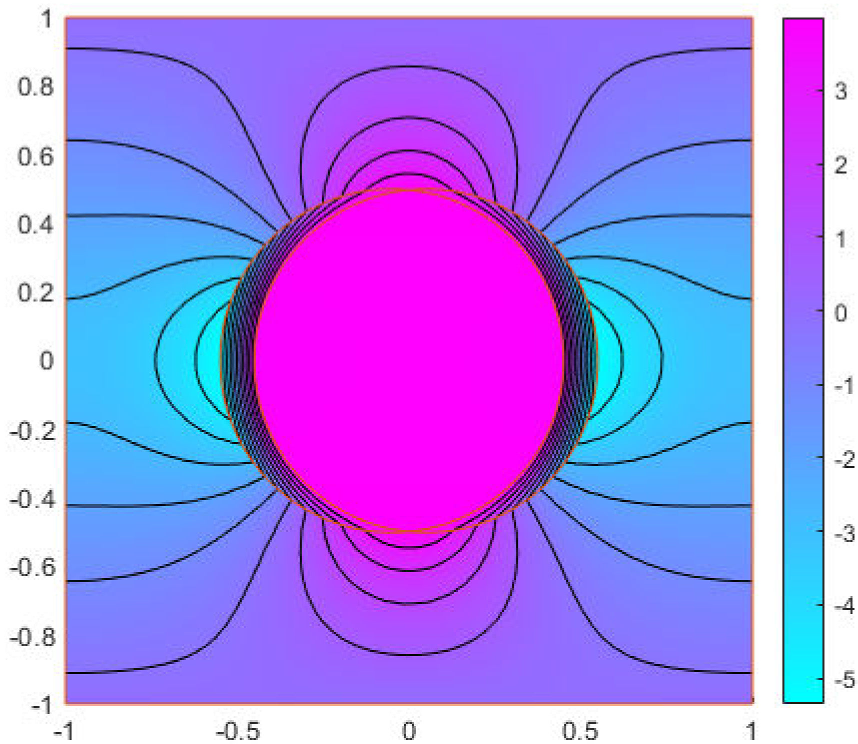
Now we are ready to solve the probelm with a call to `solvepde(),` which returns a structure `result` with all the useful properties of the solution included. We immediately use it to plot the potential u = A_z, which is available as member `NodalSolution` in the structure `result`.

```
result=solvepde(model);
figure;
pdeplot(model,'xydata',result.NodalSolution,'contour','on');
hold on; pdegplot(model)
```



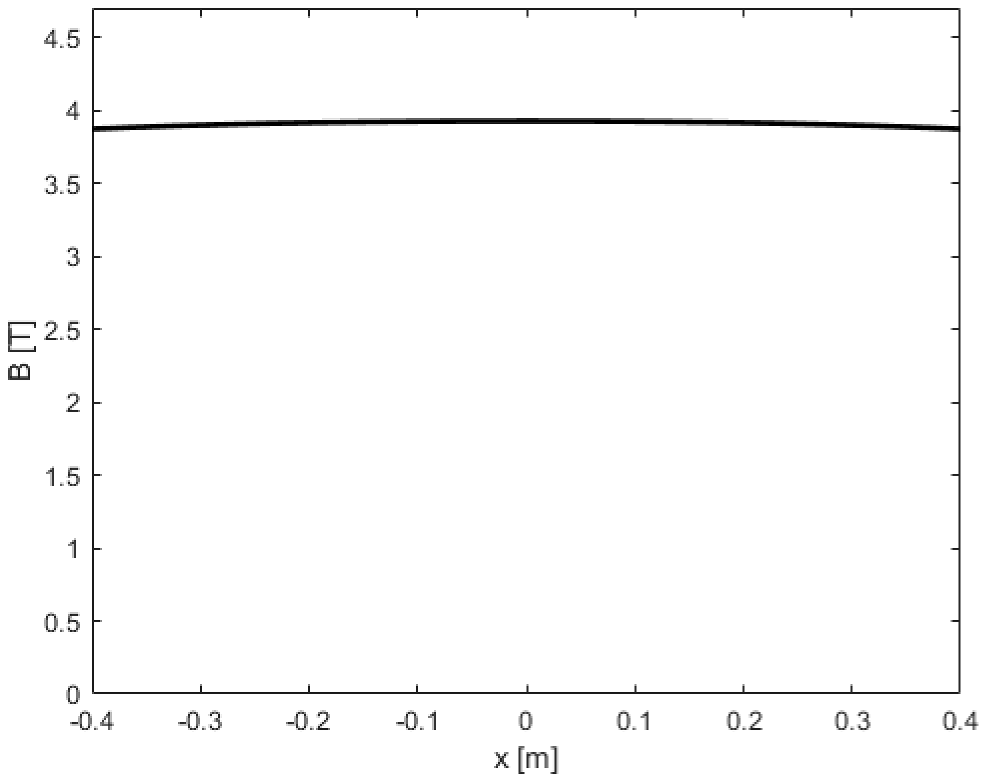
The gradients are also available in result, and we use them to determine the magnetic fields from Equation 4.10. We then plot B_y in the region and find that the field reaches almost 4 T.

```
By=-result.XGradients;
Bx=result.YGradients;
figure; pdeplot(model,'xydata',By,'contour','on');
hold on; pdegplot(model);
```



We then investigate the homogeneity of the field by plotting B_y along a line in the midplane of the magnet.

```
x=-0.4:0.01:0.4; y=zeros(1,length(x));
[dAx,dAy]=evaluateGradient(result,x,y); Bx=dAy; By=-dAx; B=hypot(Bx,By);
figure; plot(x,By,'k','LineWidth',2);
xlabel('x [m]'); ylabel('B [T]'); ylim([0,4.7]);
```


4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
B [T]
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
x [m]