Senior Design 491 - May1629 - Weekly Report 5

Advisor: Dr. Ravi Hadimani
Project: Development of "Triple Halo Coil" for Deep Transcranial
       Magnetic Stimulation
Client: Dr. Ravi Hadimani / Dr. David Jiles
Members: Wentai Wang
       Aashwatth Agarwal
       Dylan Jagger Rasmusson
Date: 10/06/2015

Summary

This week our task was to get a better in-hand experience with the softwares SemCAD and Comsol, and to complete our individual work, as per work distribution discussed in past weeks.

Group Meeting Notes

As per our previous meeting, we decided to divide our task with Dylan working in Comsol, while Aashwatth and Wentai work towards SemCAD simulation. We decided to continue our move to complete individual assigned simulation, as per the schedule.
Aashwatth and Wentai's job were to complete the sphere simulation in SemCAD. Dylan's job was to work through Comsol tutorials provided by Priyam.

Advisor Meeting Notes

Dr. Hadimani requested Ms. Priyam to send us a copy of Halo, and Triple Halo Coil, and asked us to get a better understanding of the respective coils. He also advised us to write notes for each topic we research, to review it as per our need. We then discussed our software training for SemCAD and Comsol, and our further progress towards the project completion.

Accomplishments

(by Aashwatth and Wentai)
- Completed our sphere simulation, in SemCAD.
- Gained a better experience with SemCAD simulation software.

- Able to identify how different magnetic and electric fields corresponds to different shape, and with different intensity in different areas. This helped us realize a better understanding towards meeting our product specification.

(by Dylan)
- Familiarized with Comsol
- Able to design coils using Comsol
- Able to simulate magnetic fields and induction currents
- Able to plot results of simulations in multiple dimensions

Plans for Next Week
- Continue our simulation in SemCAD for the **figure of 8 coil**. (Aashwatth and Wentai)
- Continue with other Comsol tutorials and design coils with different geometry (specifically elliptical coils)

Individual Hourly Contribution

(by Dylan)

Three tutorials were completed that gave me a good understanding of how to use Comsol effectively. I designed three different coils and simulated induced current density, magnetic flux density, and magnetic force using a few different techniques. These simulations produced results that I represented visually on surfaces and graphs.

Simulated induction currents of circular coils:

Using Comsol I designed two copper circular coils surrounded by air placed above one copper plate. After adding a voltage to the two coils I simulated the induced current density at different frequencies. The value of induced currents on the copper plate is distinguished by the color gradient.
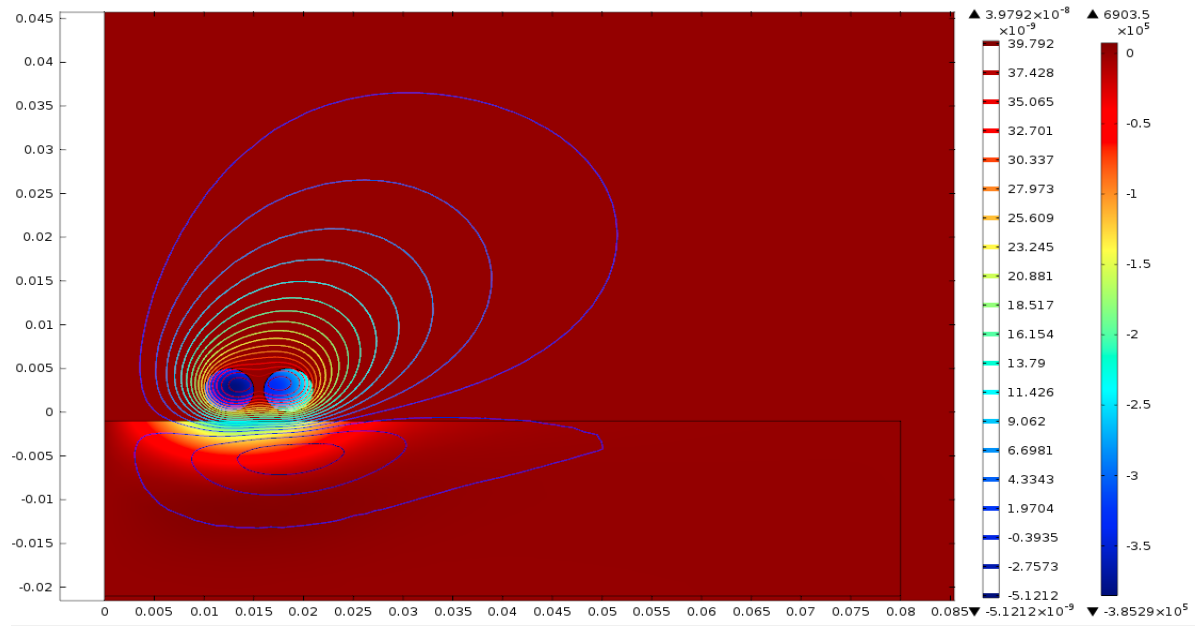

freq(3)=300 Surface: Induced current density, phi component (A/m²) Contour: Aphi*r (Wb)
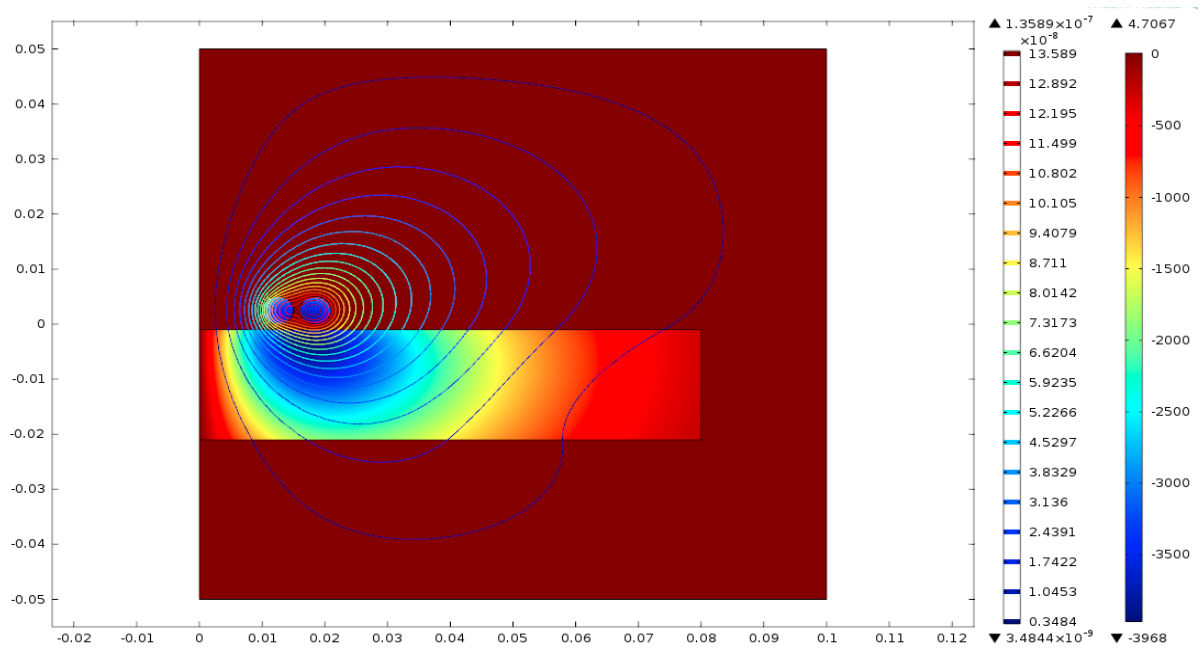
freq(1)=10 Surface: Induced current density, phi component (A/m²) Contour: Aphi*r (Wb)
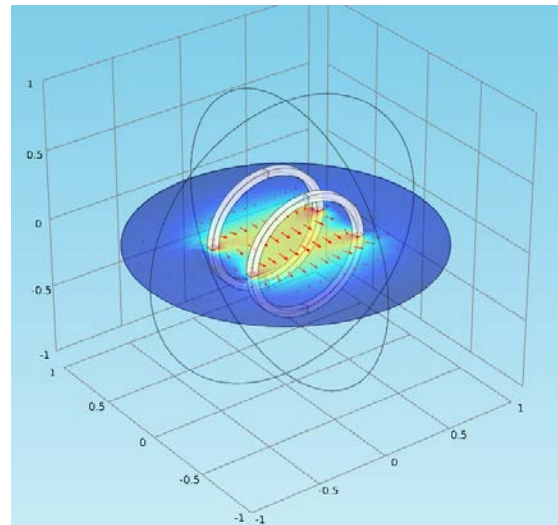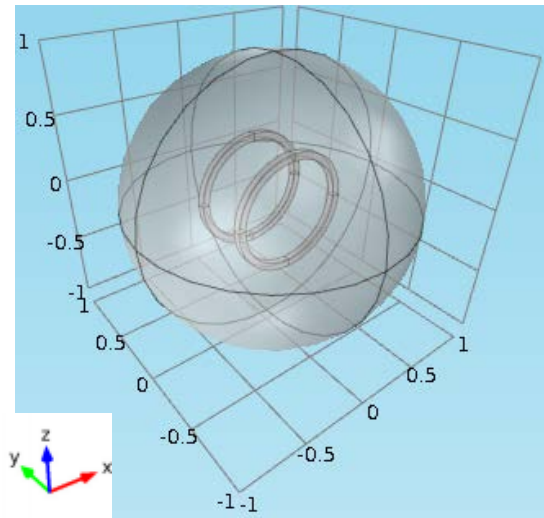
Afterwards I simulated the magnetic flux density caused by the current in the coils along with the induced current on the copper plate. The value of induced currents on the copper plate is distinguished by the color gradient while the magnetic flux density is distinguished by the arrows. The size and direction of the arrows indicate the strength and direction of the magnetic field.
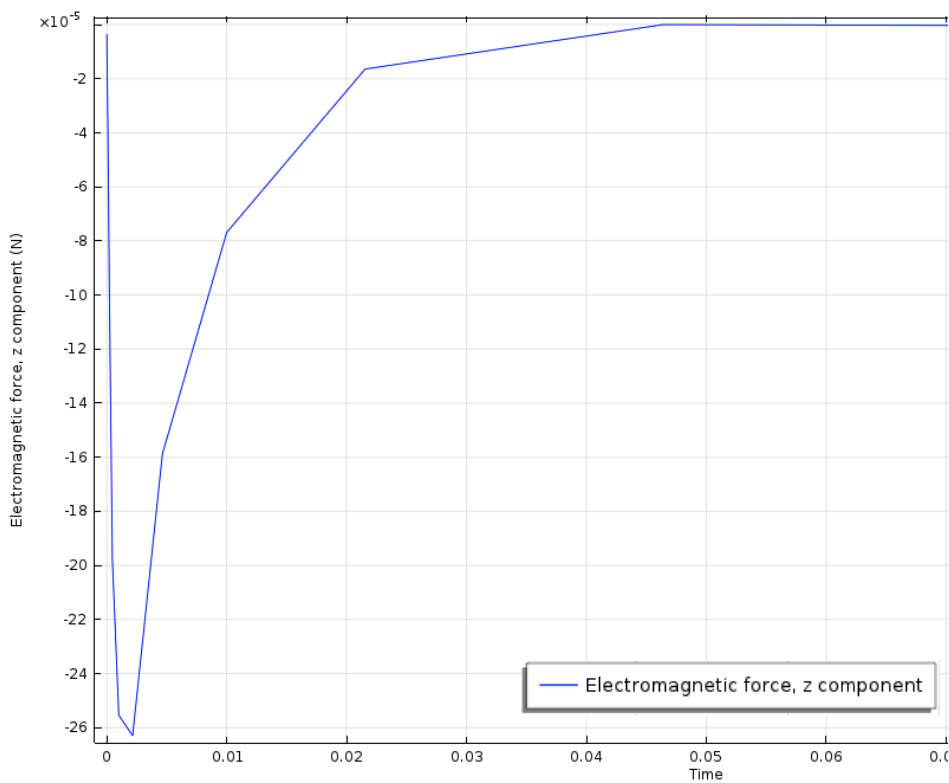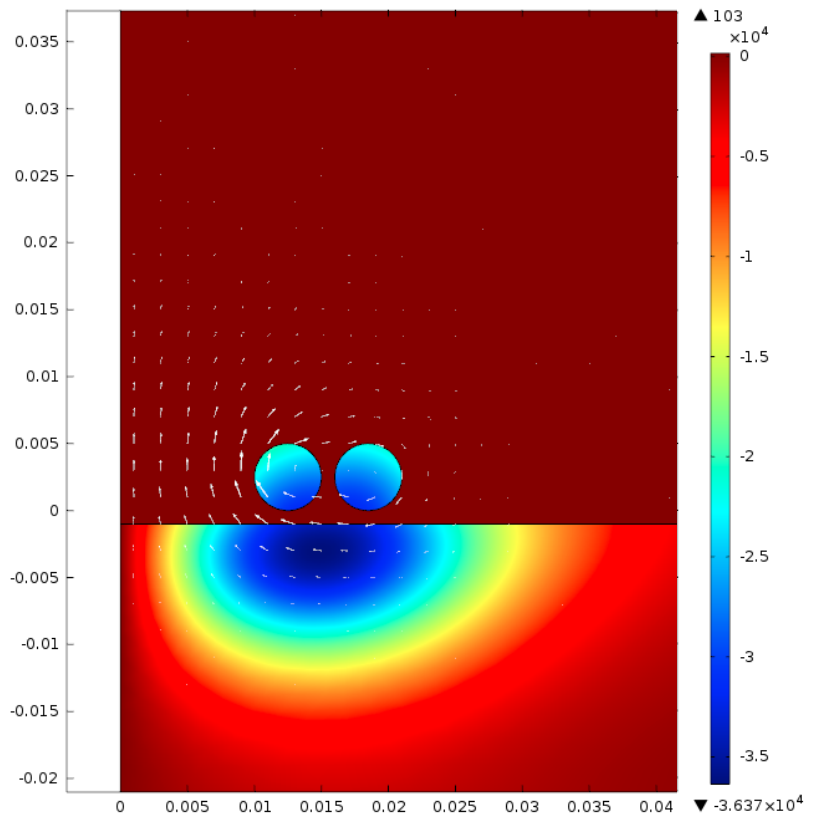
Next I plotted the z component of electromagnetic force acting on the copper plate with respect to time.

Magnetic field of a Helmholtz Coil

       I designed two identical parallel coils surrounded by air within a spherical environment and set the current density within the coils (left). I then plotted the magnetic flux density, distinguished by the color gradient, on the x-y plane of the sphere (right). The arrows indicate the magnetic field strength and direction.

Electromagnetic forces on parallel current-carrying wires

       I started by designing two simple parallel wires with defined external current densities. Then I simulated the magnetic flux within each wire indicated by color gradient and the Maxwell surface stress tensor of each wire indicated by arrows.
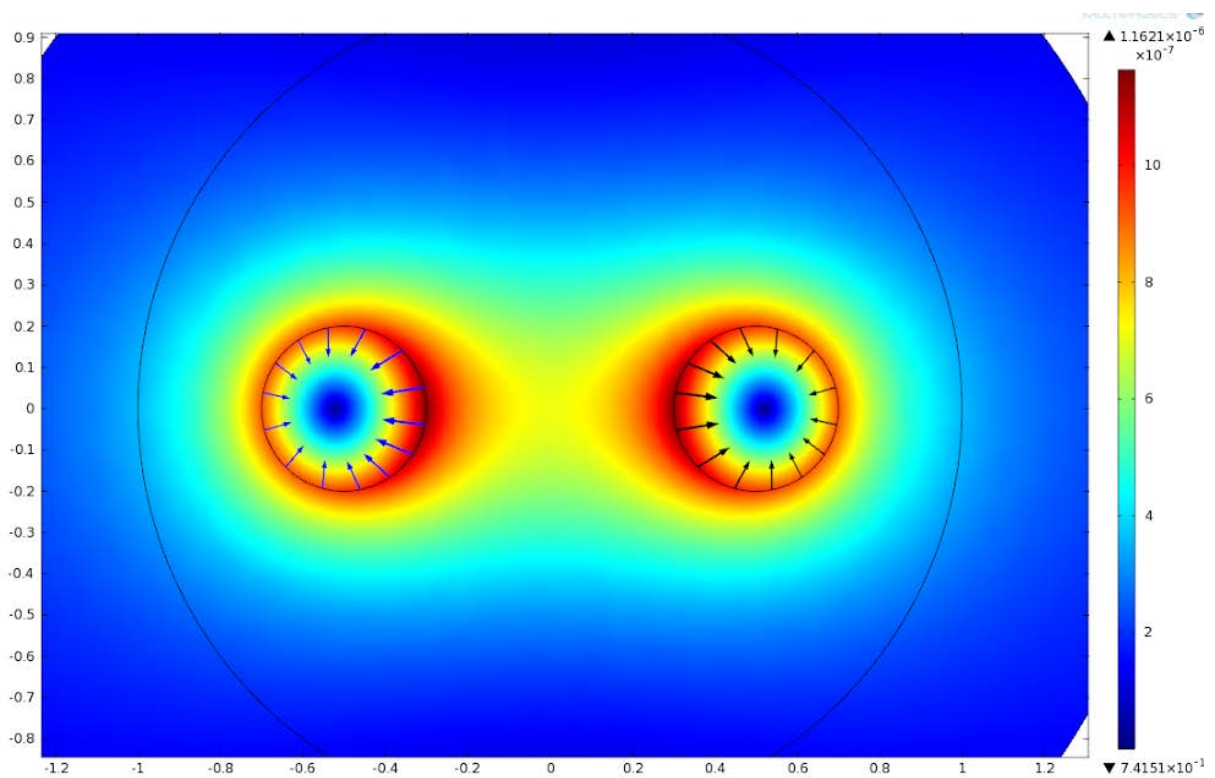
I then derived the x component of magnetic force from the Maxwell surface stress tensor of each wire.

Electromagnetic force, x component (N)	Electromagnetic force, x component (N)
-1.0966e-7	1.0928e-7

Following this derivation, I derived the x component of the magnetic force again using Lorentz' Force.

| Lorentz force contribution, x component (N/m)	Lorentz force contribution, x component (N/m)
-1.0997e-7	1.0998e-7

After comparing the two sets of results it is clear that Lorentz Force is slightly more accurate.

(by Aashwatth and Wentai)

As per our team discussion, we continued to work on our divided section. To get a first hand experience with SemCAD, Ms. Priyam offered us a training on Semcad. After the training, our first work was to simulate a sphere on SemCAD, in order to move forward to design our respective coil, and to learn towards the implementation of the required specification. For sphere, we comprised our circular coil design of 15 turns with internal radius 33.5 mm. After setting and configuring sources, we obtained our simulation result. The following is our Magnetic and Electric field view, with 2-D charts:

Electric Field view:
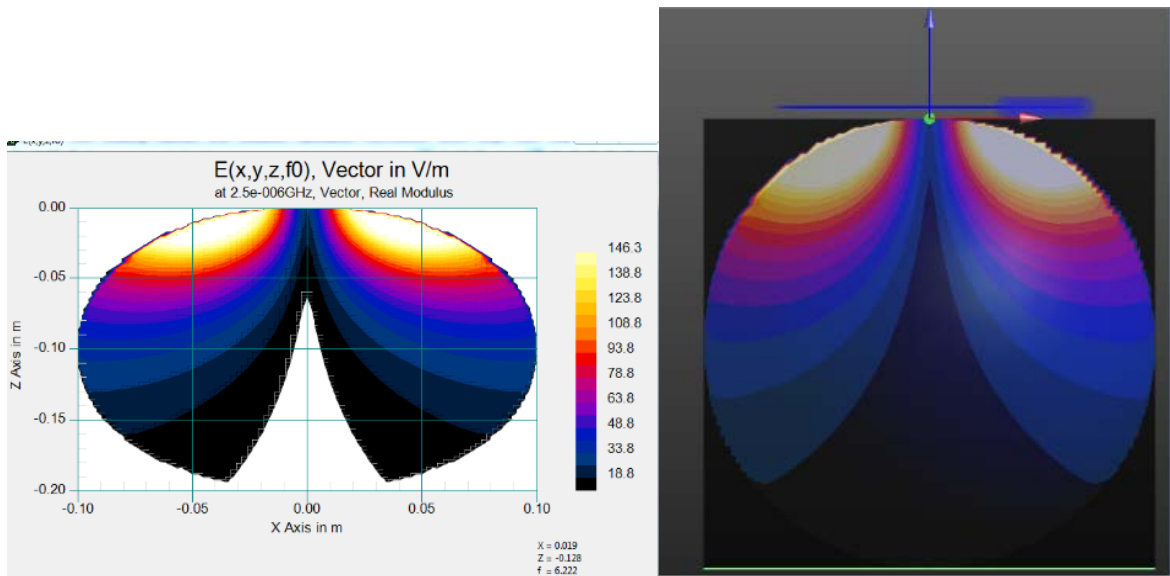
Magnetic Field view:
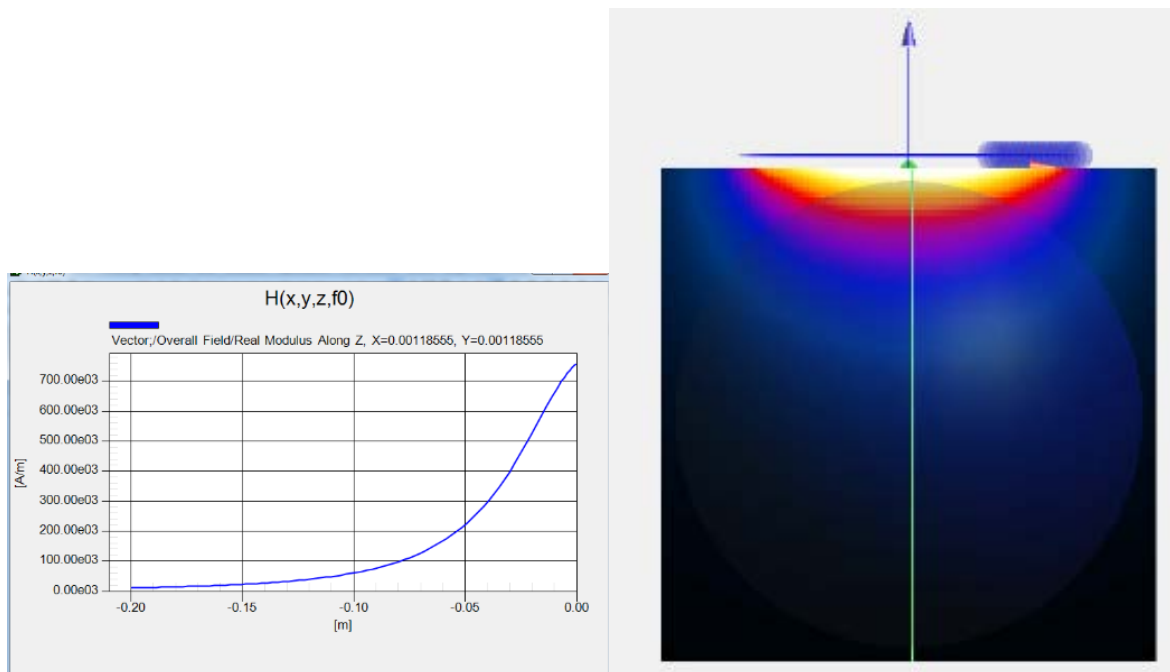
Name	Hours this week	Work
Wentai Wang	6	SemCAD simulation, weekly reports, meetings
Aashwatth Agarwal	6	SemCAD simulation, weekly reports, meetings
Dylan Rasmusson	6	COMSOL, weekly reports, meetings