**Electromagnetic Simulations**

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ENGR 105: Introduction to Scientific Computing – Project Summary

**Project Scope**

This project consists of 11 customizable simulations that model electromagnetic phenomena. The electric and magnetic fields from both common and arbitrary systems are calculated and plotted using numerical methods. The motion of a charged particle in uniform electric and magnetic fields is also included. The program simulates fields that would be difficult to solve analytically, such as that of a finite wire or square loop of charge. The visualisation of fields that this project provides is useful for learning the fundamentals of electrodynamics.

**Program Structure**

Firstly, the user selects a simulation from a drop down menu. The GUI then updates with the appropriate input fields and editing options. The user can input data that is relevant to the current simulation such as position of point charges or radius of solenoid etc. The data is extracted from the GUI, validated, analyzed and stored within the *handles* data structure to allow access across the EM.m file.

When the user requests to plot the data the program calls external function(s) that calculate the electric and/or magnetic fields using classical electrostatic and magnetostatic theory. The resulting data is returned to the main function (EM.m), which then plots the results to the GUI.

The principle of superposition is used throughout the project to maximize the reuse of code. For example, the field from a line of charge can be approximated by the superposition of many point charges arranged in a line. Therefore the code used to calculate the field from individual point charges can be reused.

**Program Challenges**

This was a challenging project that required wide use of MATLAB’s capabilities. For instance, correctly calculating the numerical integration (Riemann sum) of the electric and magnetic fields in both 2D and 3D space was difficult and required knowledge of Cartesian, spherical and polar coordinate systems. Moreover, many EM fields are proportional to (1/r2) and therefore tend to blow up close to the source charge. Introducing a minimum distance between where the field is calculated and the source charge solved this particular problem. Care was taken to split the overall program into many functions to help with clarity.

**Omitted Functionality**

All simulations mentioned in the project proposal were implemented. The field from a square loop of charge, charged disk and bar magnet were also included. I decided not to include a simulation to solve Laplace’s equation for the electric potential since MATLAB already contains comprehensive partial differential equation solving capabilities (See PDE app).

**Sample Screenshot**

