Electric Field Plots for Various Charge Distributions

Physics 77 Capstone Project

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Theory

The electric field around a point charge Q is given by

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{\mathbf{r}} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^3}\mathbf{r} \tag{1}$$

Where $\mathbf{r}$ is the position vector of the test charge.
The electric field for a continuous charge distribution is obtained by a volume integral

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\iiint_V \rho(\mathbf{r}')\frac{\mathbf{r}-\mathbf{r}'}{|\mathbf{r}-\mathbf{r}'|^3}dV(\mathbf{r}') \tag{2}$$

where $\mathbf{r}$ and $\mathbf{r}'$ are the position vectors of the test charge and volume element, respectively, and $\rho(\mathbf{r}')$ is the charge density at location $\mathbf{r}'$.

Charge distributions objects

Figure: Dipole

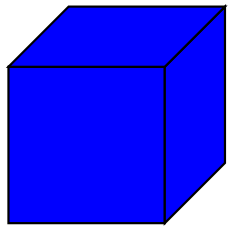


Figure: Cube

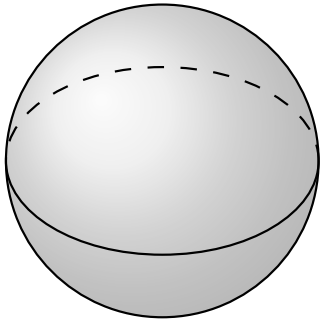


Figure: Sphere

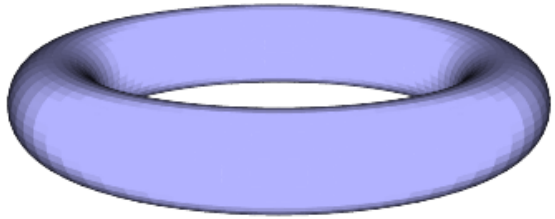


Figure: Torus

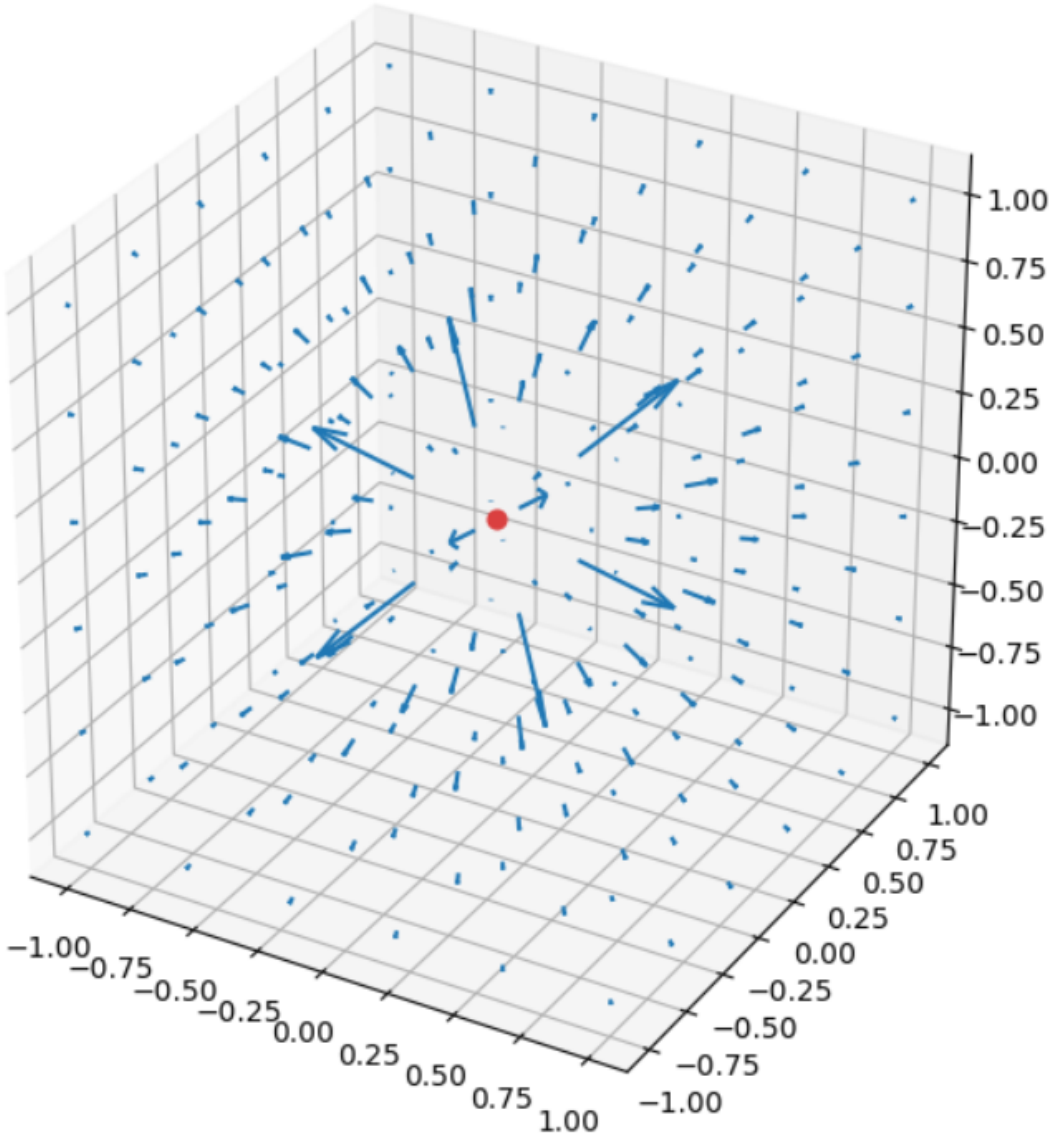
Methods

I The fields around the point charge and dipole will be calculated using equation (1).

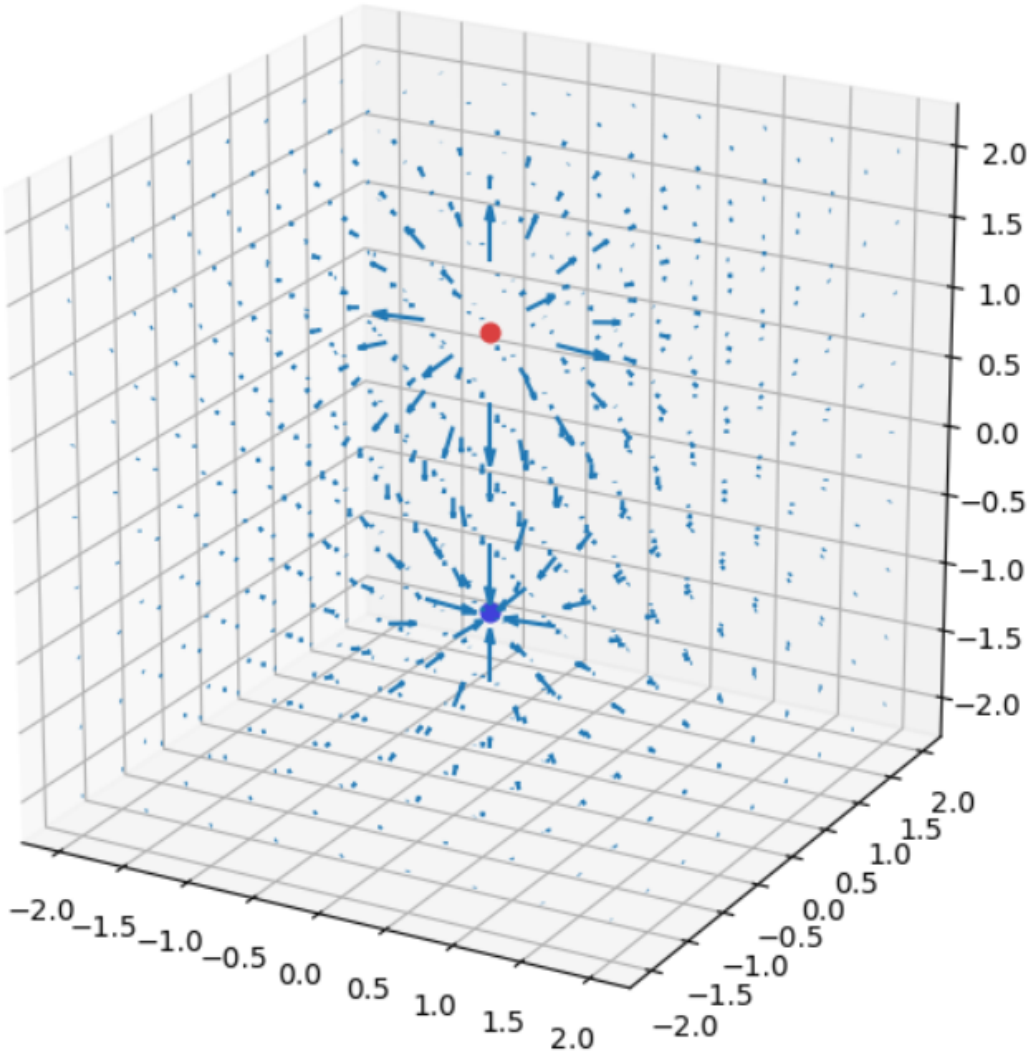
II The rest of the fields will be computed using equation (2) and numerical integration.

III Vpython and the *quiver3d* function from the *matplotlib* library will be used to produce the plots.

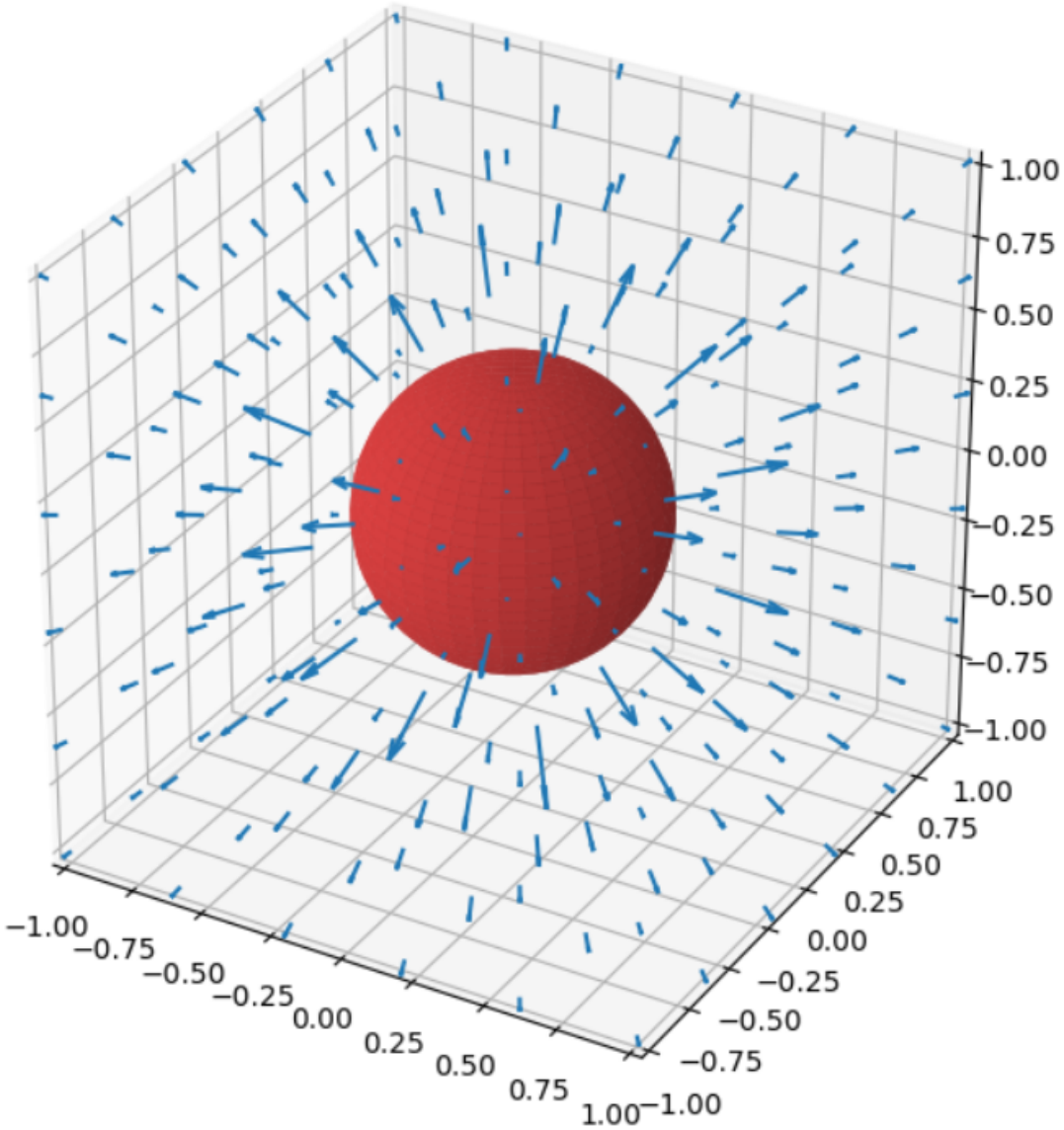
Vector Field for Point Charge



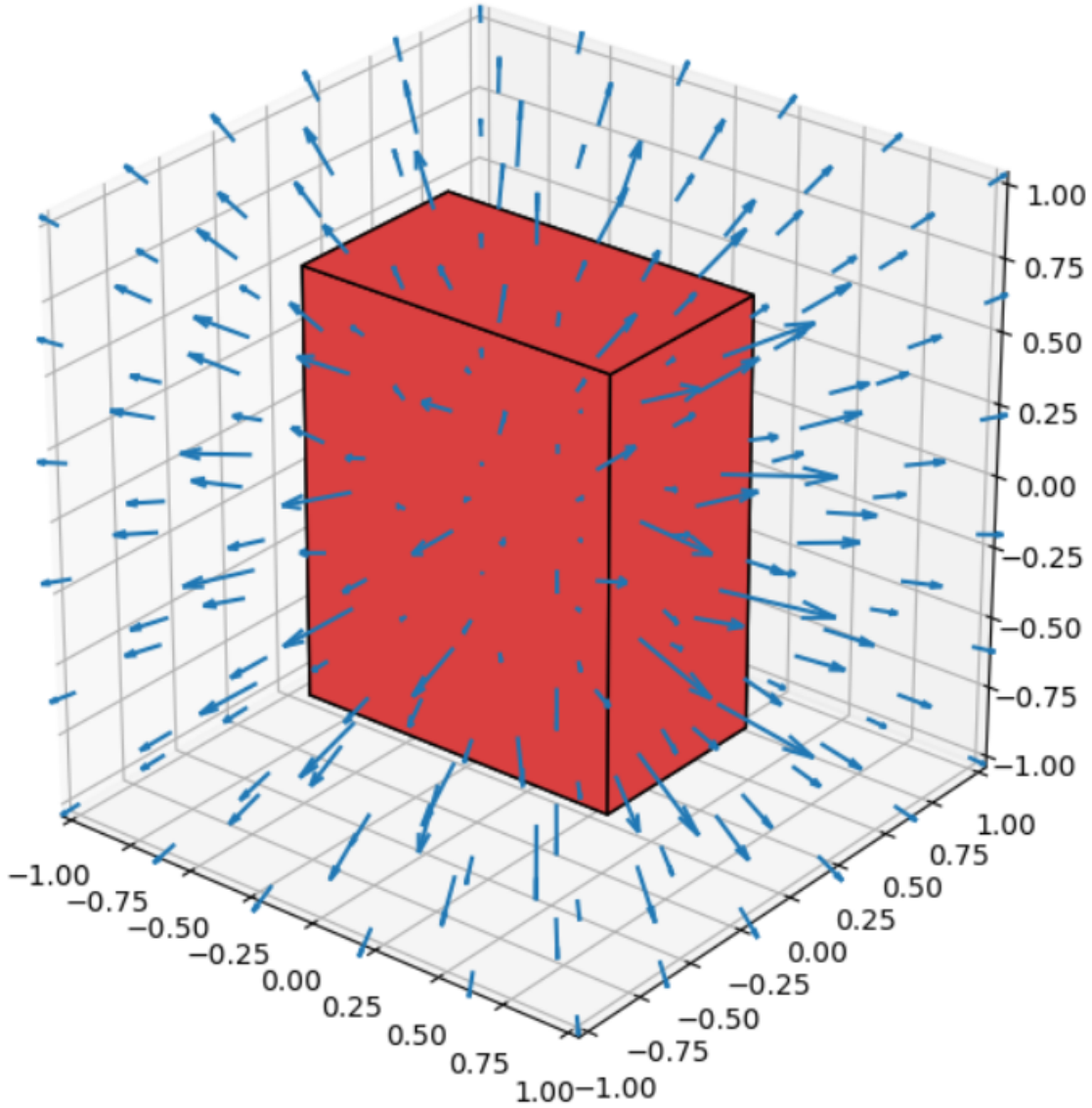
Vector Field for Dipole



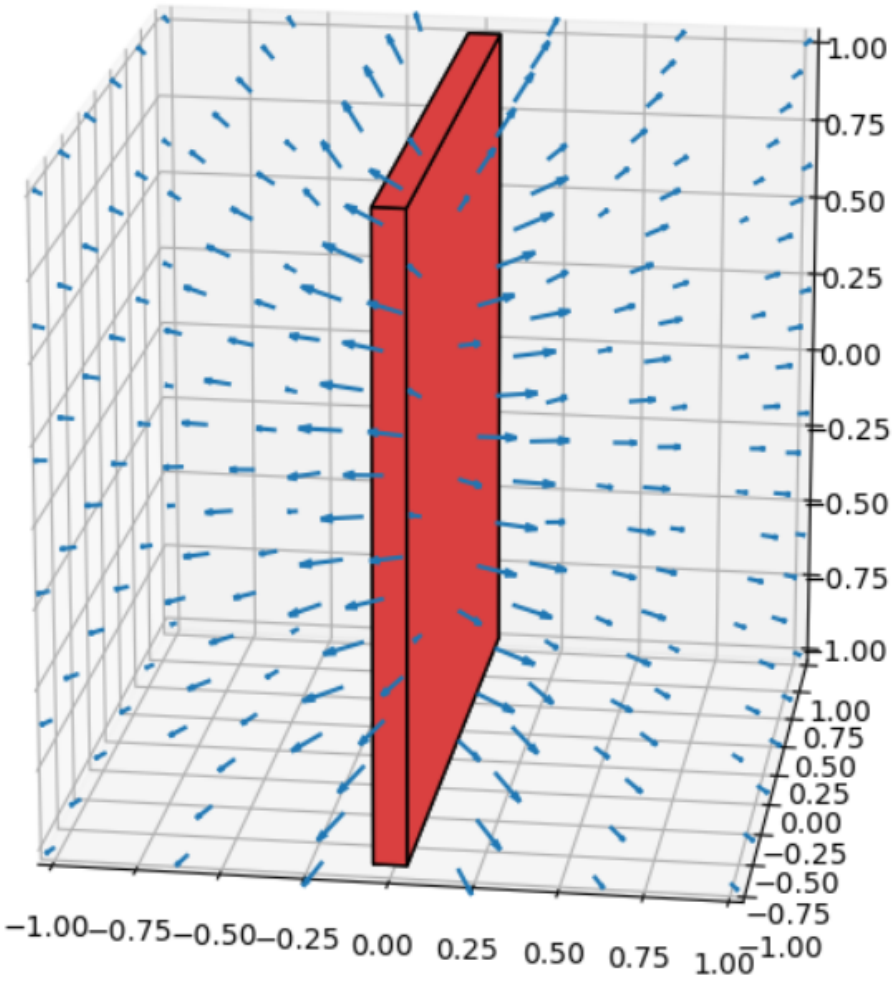
Vector Field for Uniformly Charged Sphere



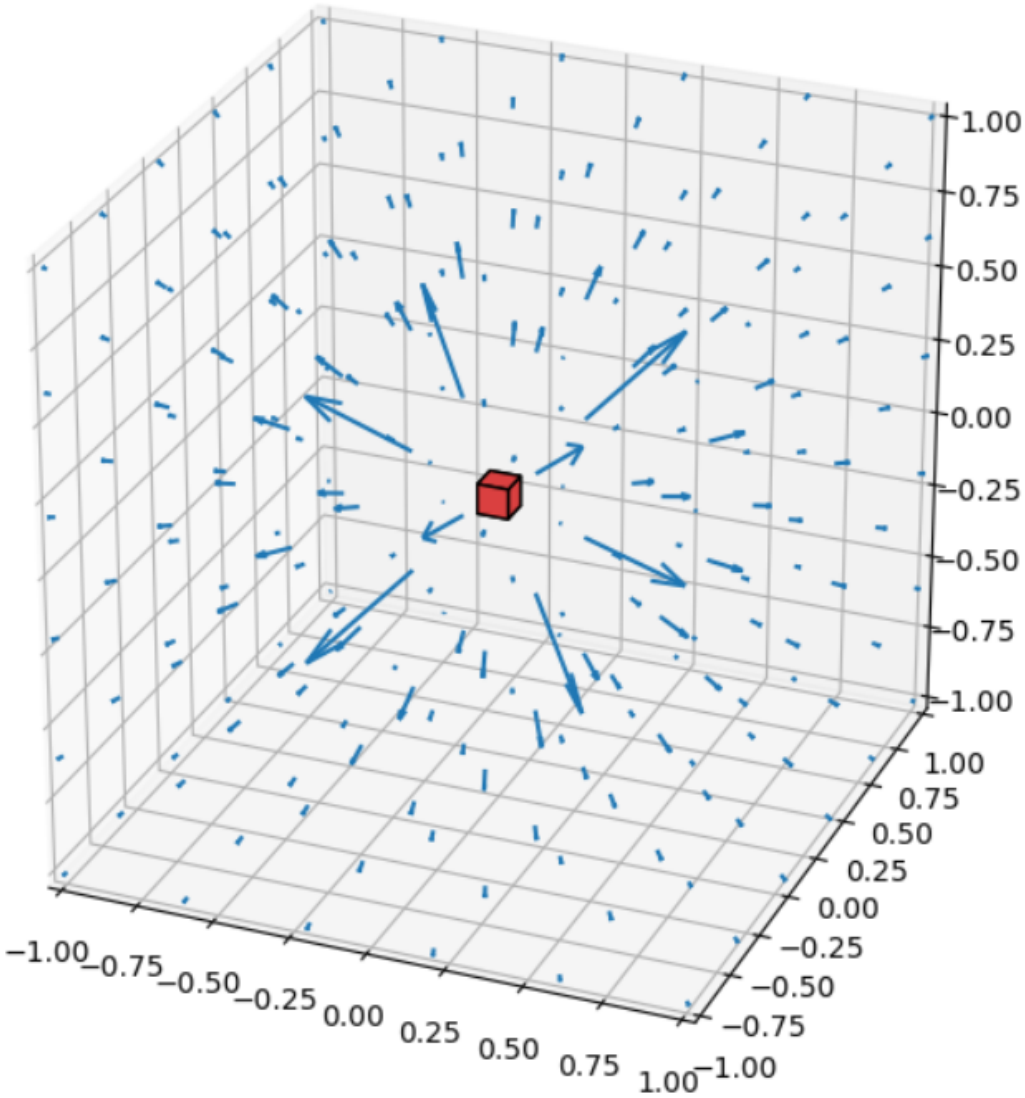
Vector Field for Charged Slab



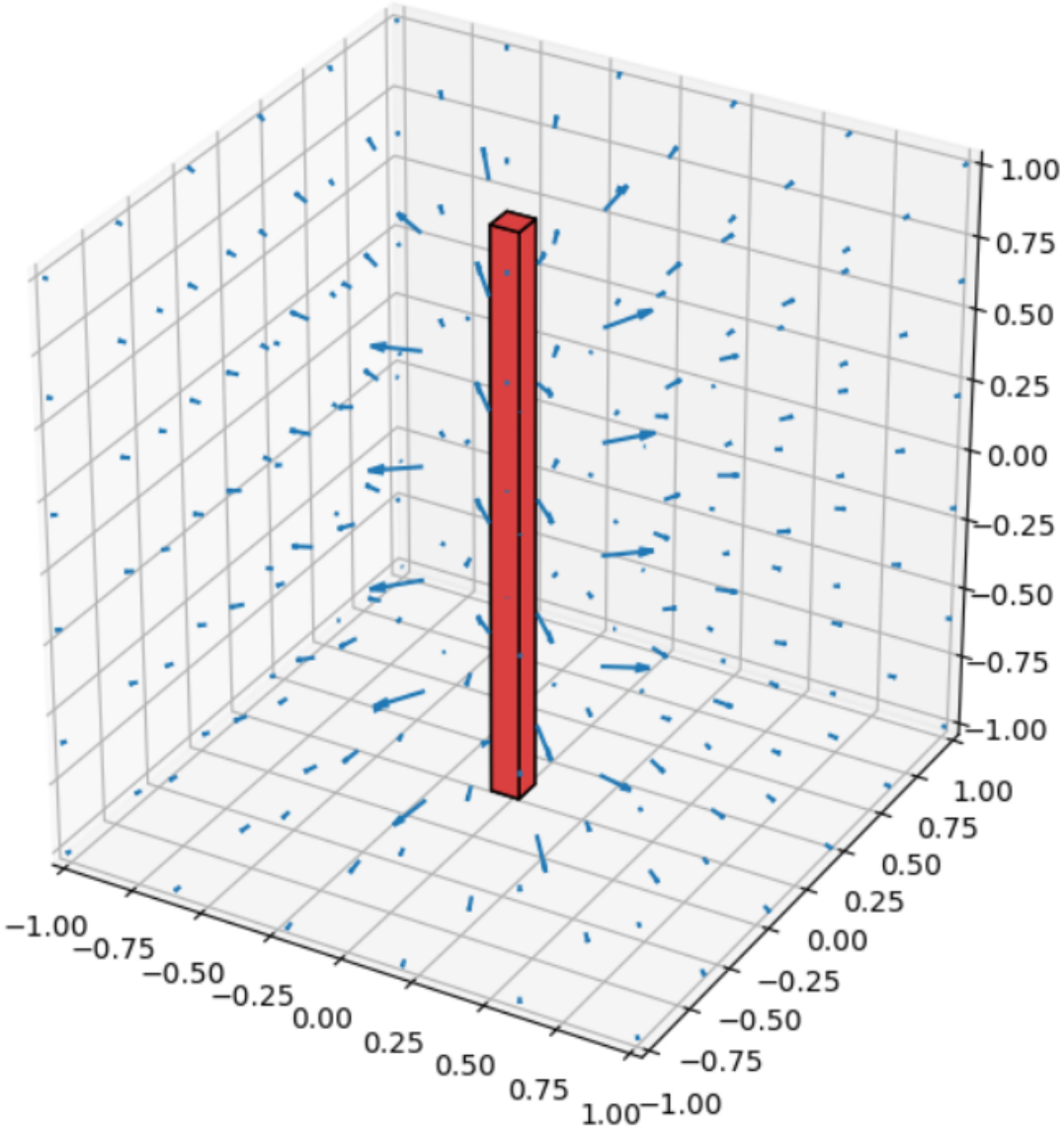
Vector Field for Plane



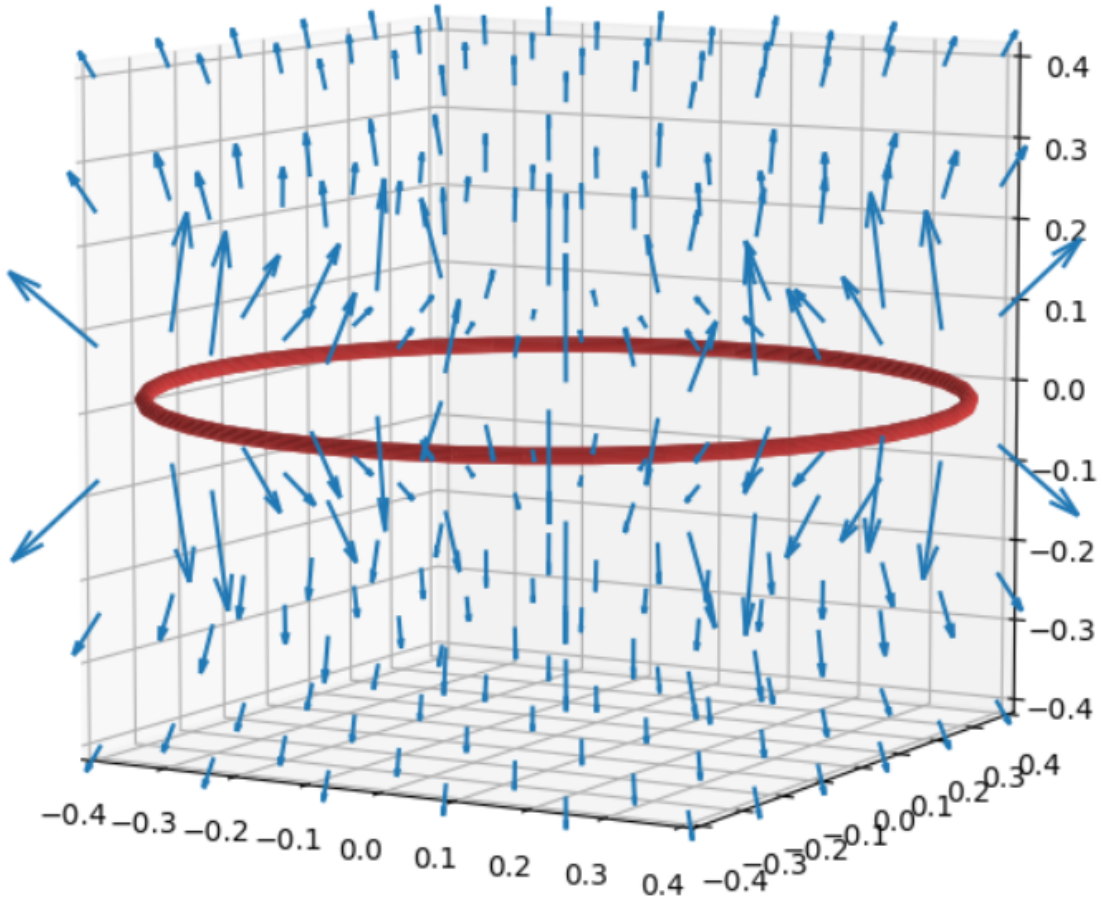
Vector Field for Tiny Cube (Point)



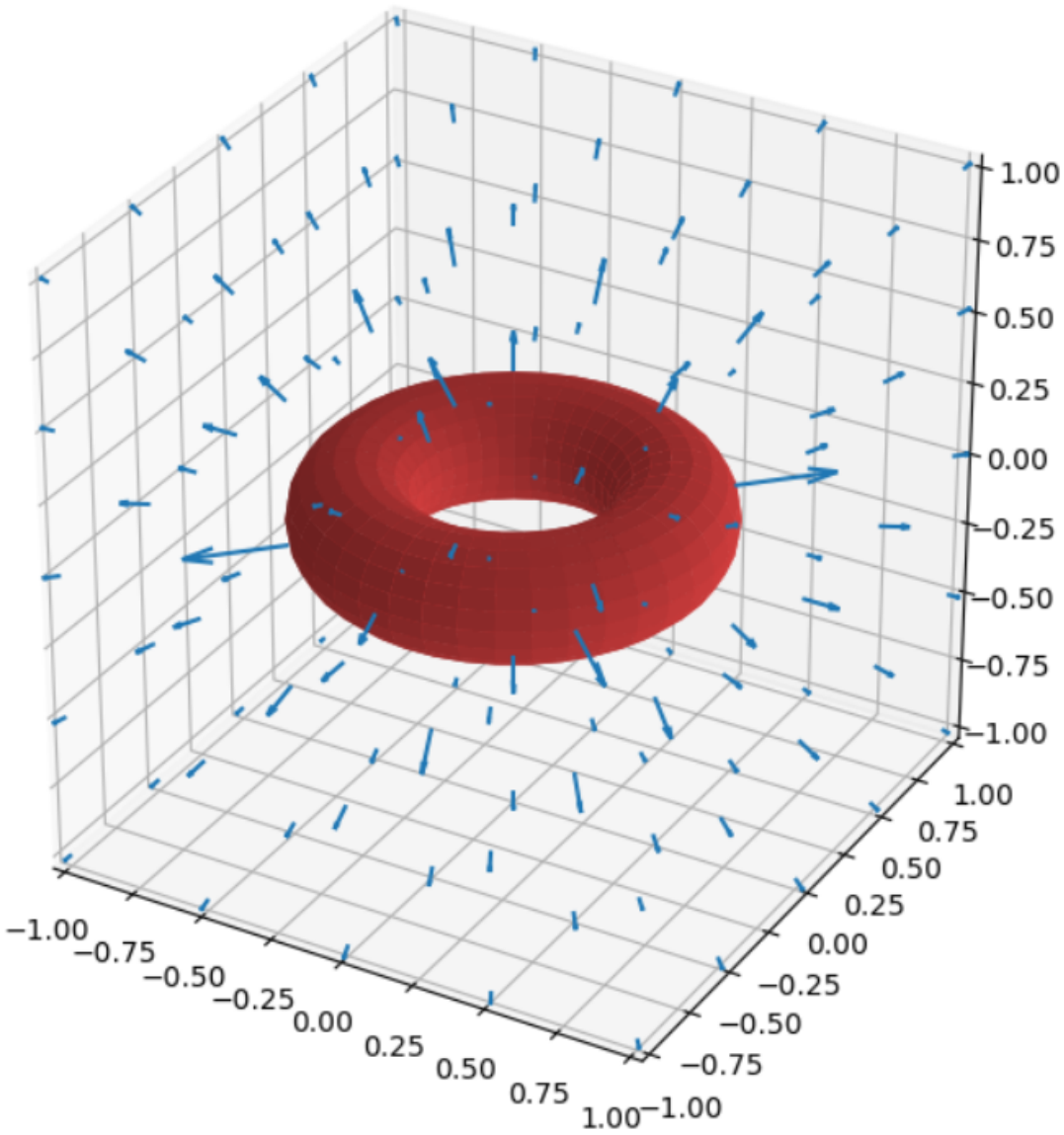
Vector Field for Rod



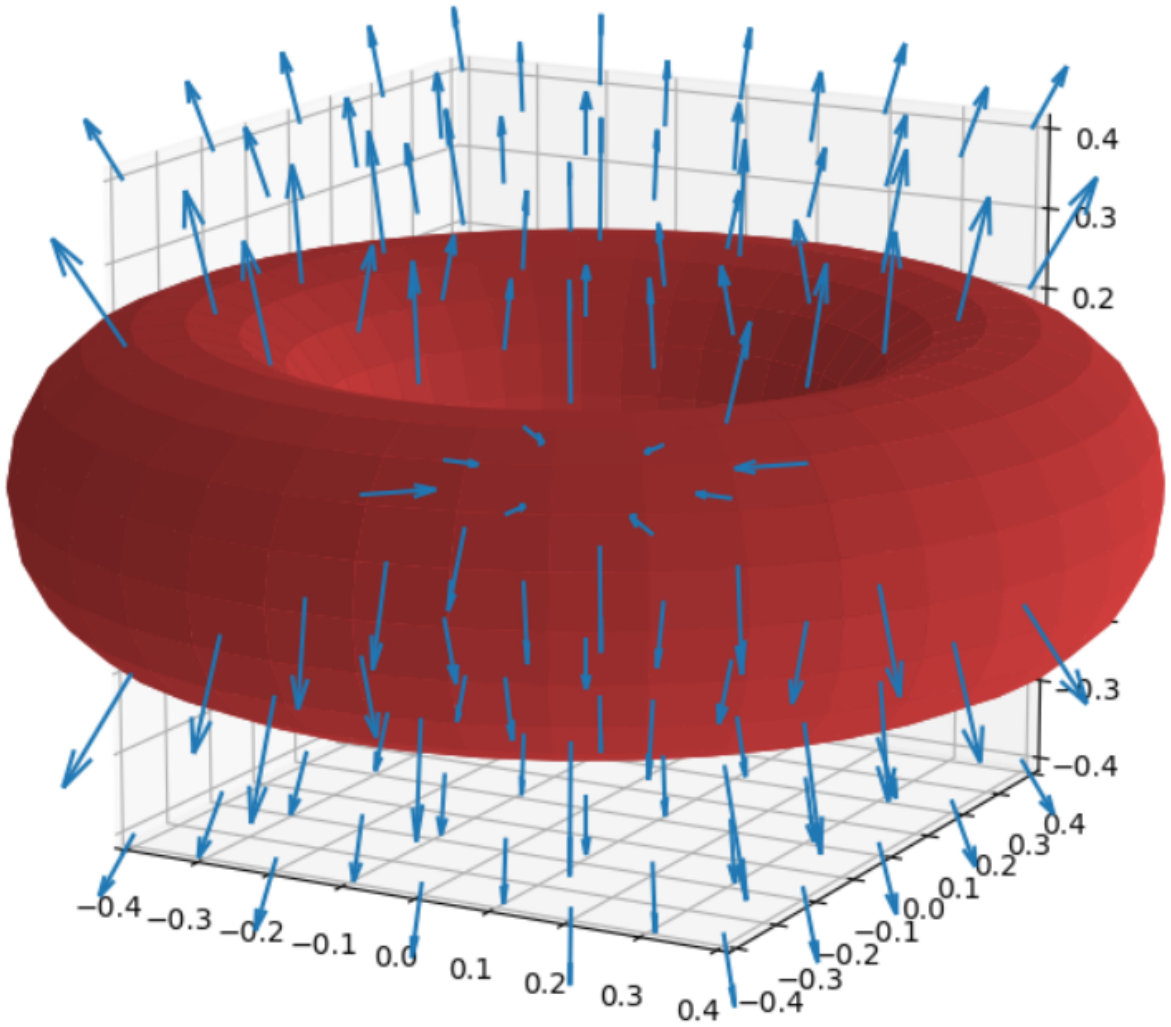
Vector Field for Ring



Vector Field for Torus



Vector Field for Torus



References

E. M. Purcell and D. J. Morin, *Electricity and Magnetsim*, Third Edition, Cambridge Univ. Press, 2013.