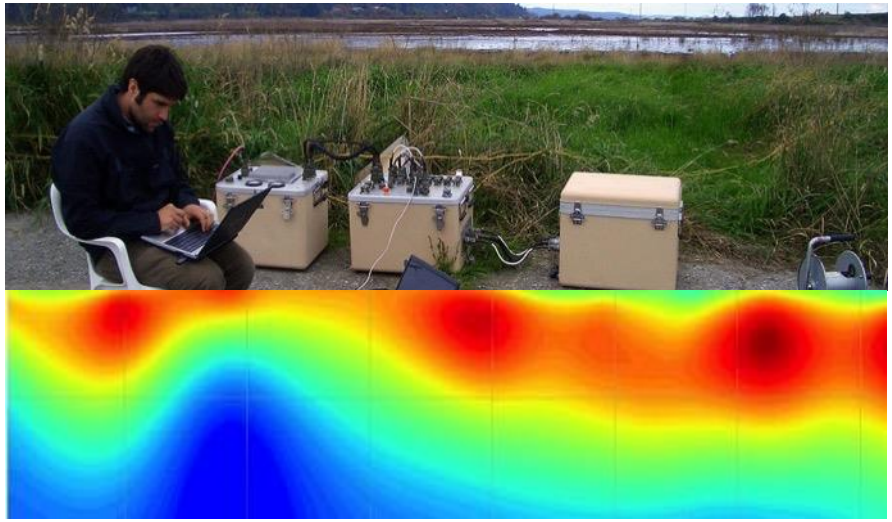
EOSC 350 : Environmental, Geotechnical and Exploration Geophysics I

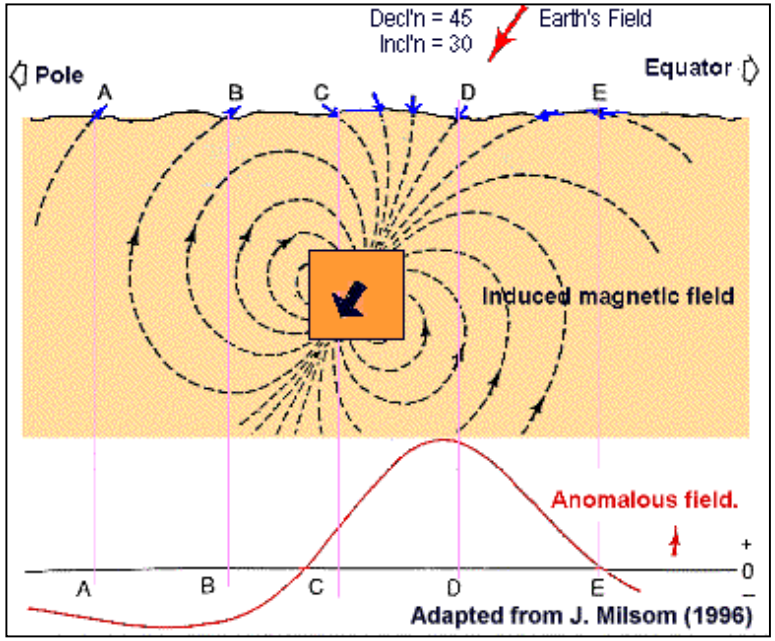
EM Introduction



September – December, 2017

EM =

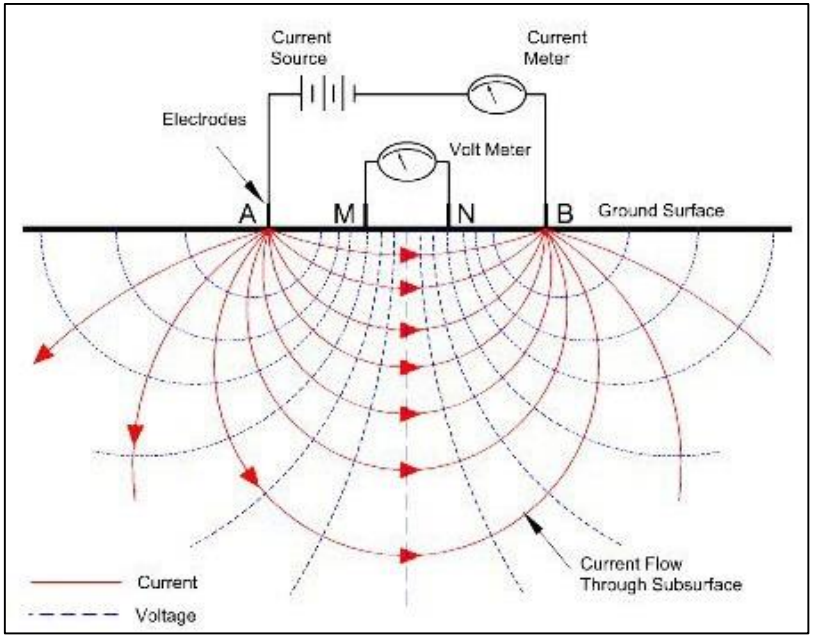
Magnetics



- Magnetic dipole
- Magnetic flux (B)

+

Electric Resistivity

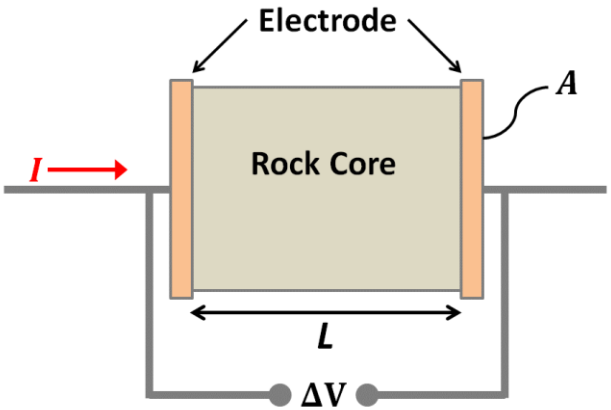


- Electric dipole
- Electric current (J)

Electrical energy transmission

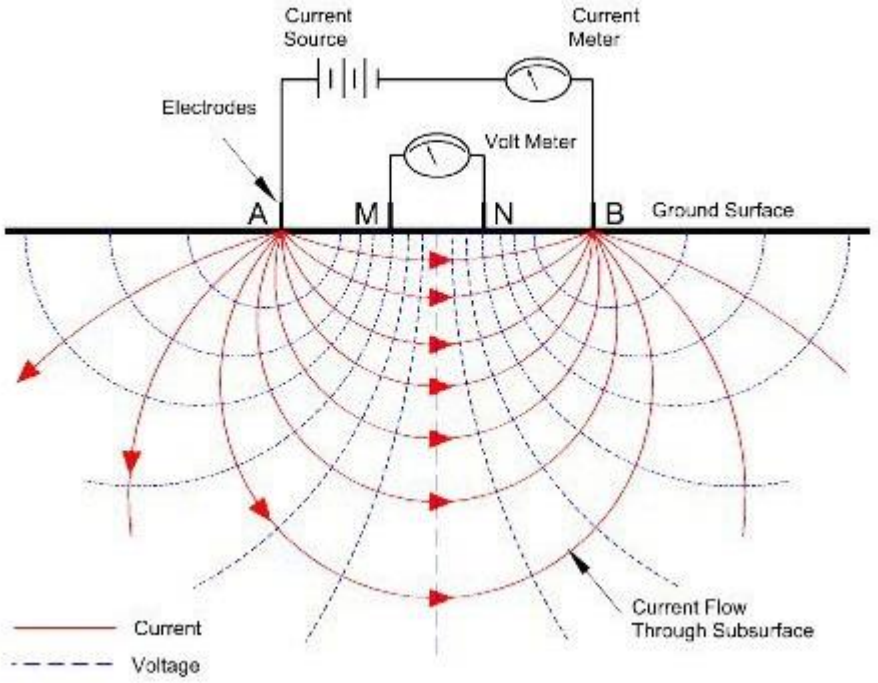
- Galvanic (electric current)

Ohm's law



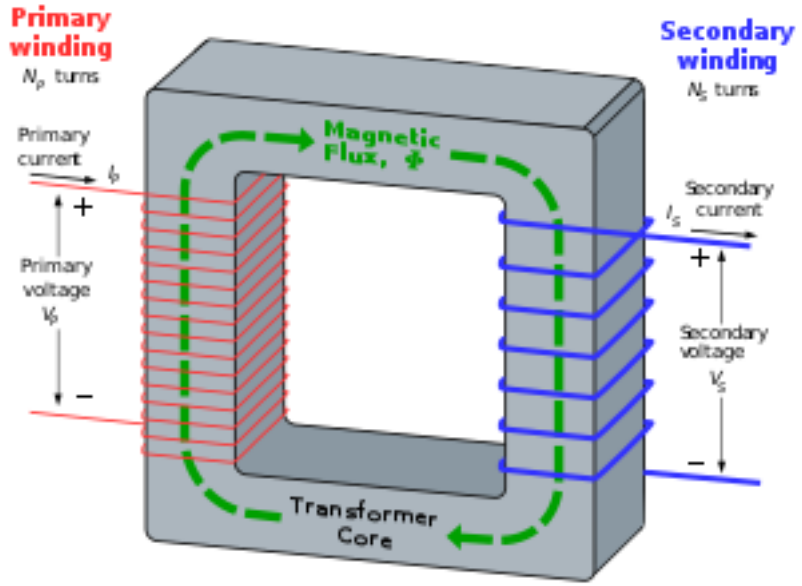
$$R = \frac{\Delta V}{I}$$

DC resistivity
(electric resistivity tomography)



Electrical energy transmission

- Inductive (magnetic flux B)



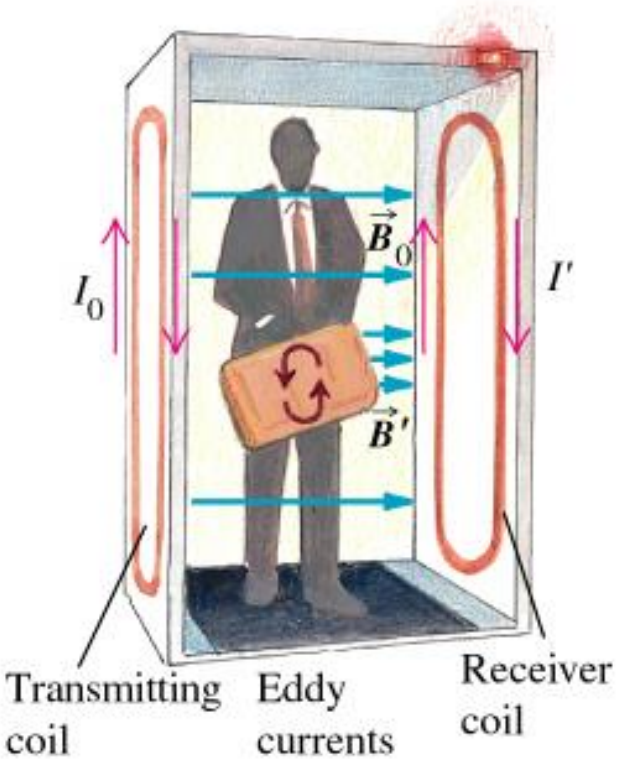
1. Change of current in the primary
2. Change of magnetic flux in the core
3. Induced current in the secondary

A transformer:

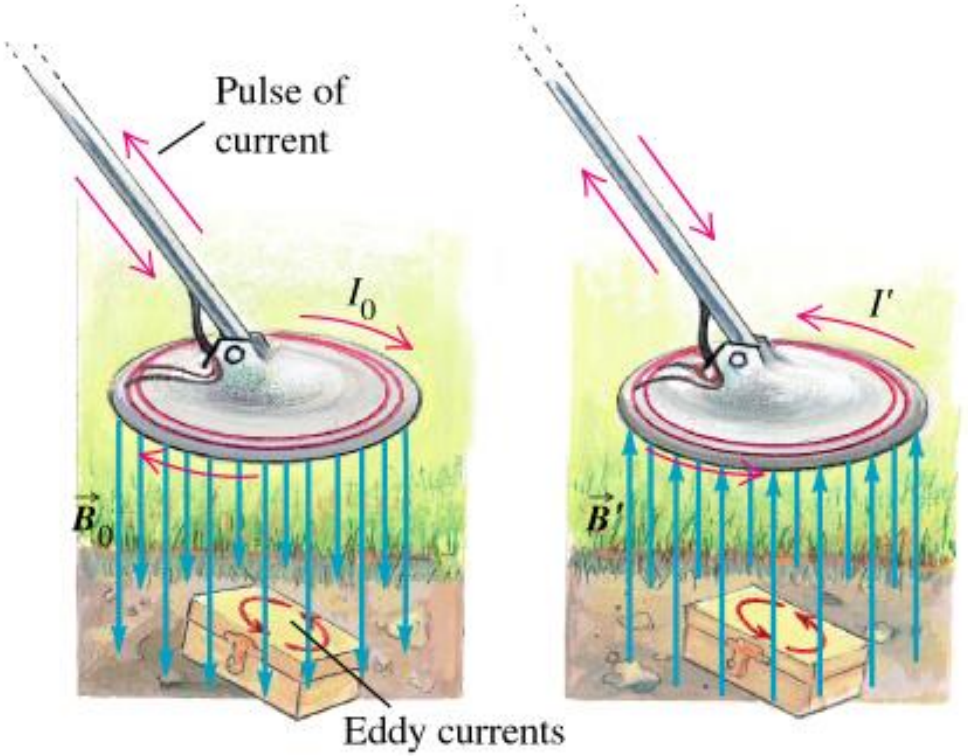
- No direct connection between primary and secondary windings
- Energy goes through in the forms of electric, magnetic then electric
- Magnetic flux linkage only in AC (requires non-stationary current)

Electrical energy transmission

- Inductive (magnetic flux B)



Security scan



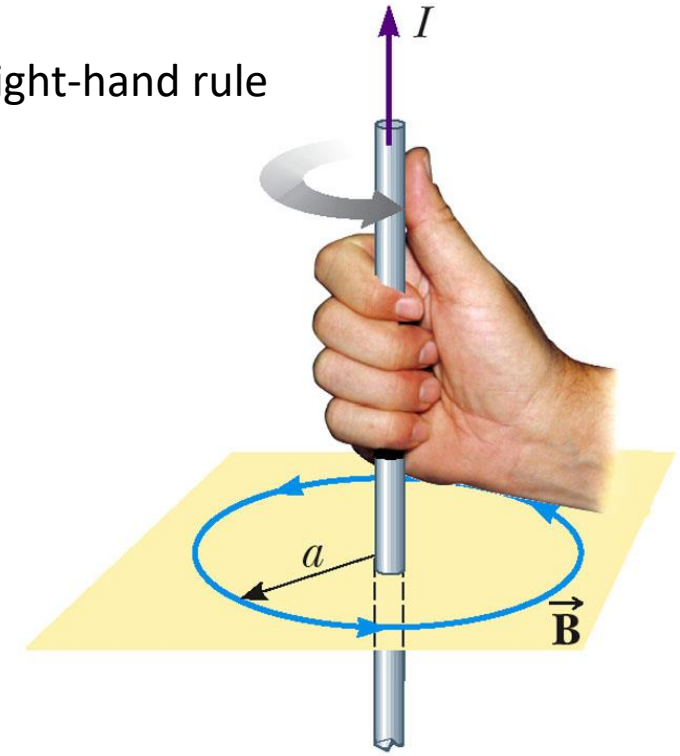
Metal detector

Ampere's law

J generates B $\quad \nabla \times \mu^{-1}\mathbf{B} = \mathbf{J} = \sigma\mathbf{E}$

Current in wire causes a magnetic field to sur-round it (iron filings).

Right-hand rule



Ampere's law

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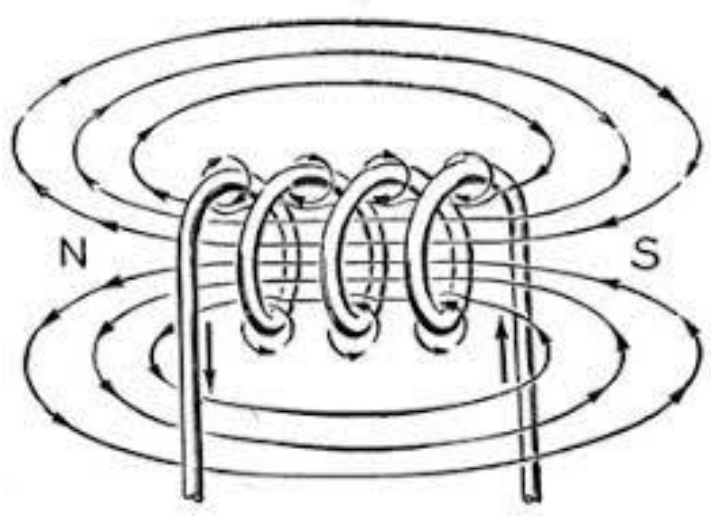
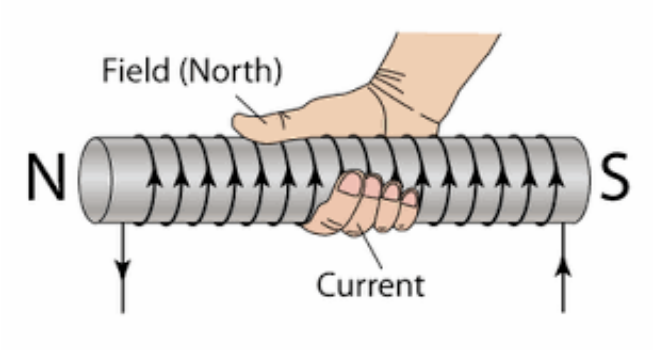
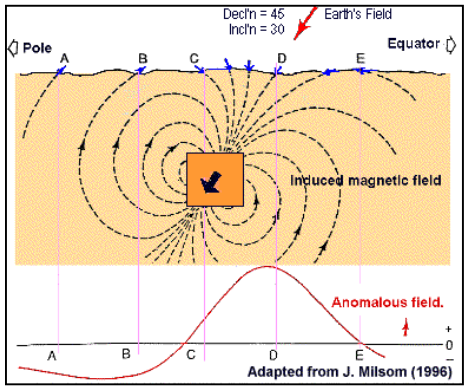




A small solenoid generates a magnetic field that can be approximated by a magnetic dipole (or a small bar magnet)

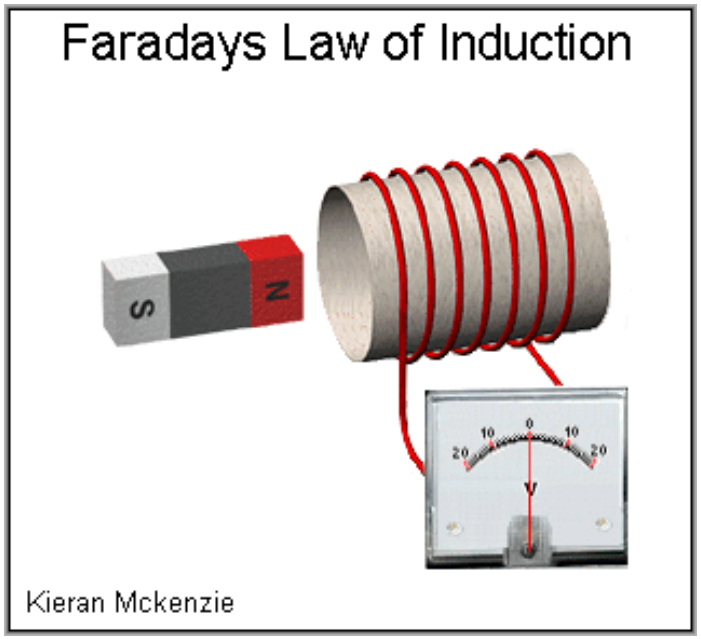


Still remember the magnetic dipole?

Faraday's law

Change of B generates J

$$\nabla \times \sigma^{-1}\mathbf{J} = \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

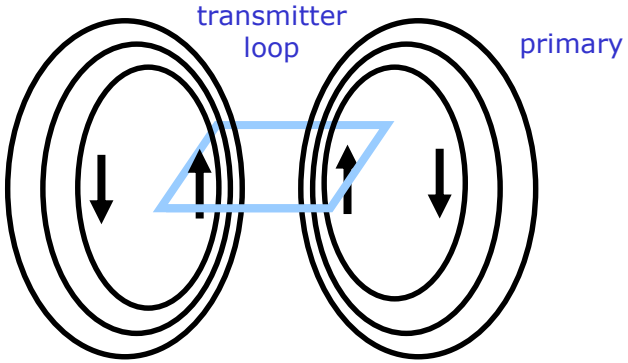


Induced current depends on

- How fast B changes
- How many B-field lines go through
- How conductive the object is

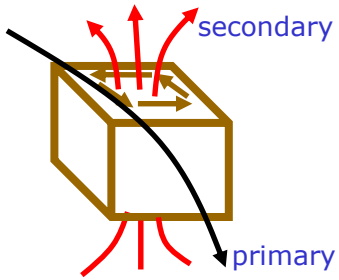
Communicate with the earth

Transmitter loop



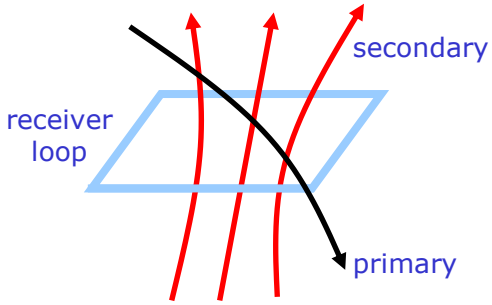
Ampere: time-varying current and changing primary magnetic field

Target



Faraday: current induced by the changing primary field;
Ampere: induced current generates a secondary magnetic field

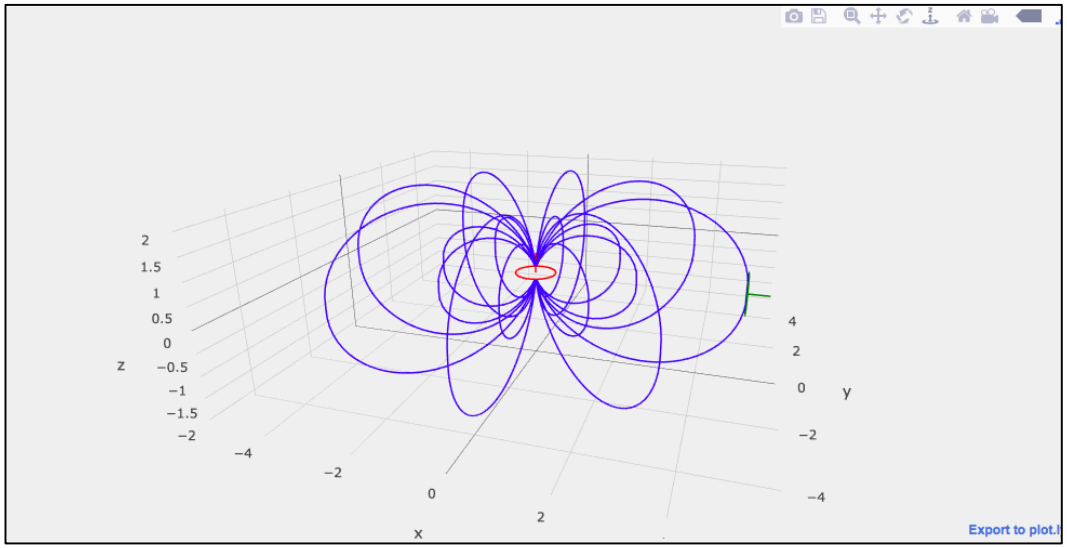
Receiver loop



Faraday: measurable current induced in the loop by the changing secondary field

Notebook: Loop, dipole and field lines

- Hands-on practice in TBL teams
- “MagDipoleLoops3D.ipynb”
- Clone or download from https://github.com/yangdikun/magLab.git
- Finish the following tasks in teams



Tips:
The buttons on the top-right corner of the figure area can help you zoom, pan and rotate.

Task 1: Loop by default

- “Run All” to get the default result
- Shown is a loop wire carrying an 1A current. The equivalent dipole moment is calculated as the product of loop area and current. Your estimate of the dipole moment is _____.
- The straight line perpendicular to the loop surface indicates the direction of the dipole moment. The plot you see represents a ***horizontal*** or ***vertical*** loop with a ***horizontal*** or ***vertical*** dipole moment. (circle one of the two choices)

Task 2: Reorient loop

- Adjust the declination and inclination of Loop 1, so the dipole moment points to the +x direction. Now the loop represents a ***horizontal*** or ***vertical*** dipole. (circle one of the two choices)
- Take a screenshot of the figure and paste it below. Remember to include the axis labels.

Task 3: Loop-loop coupling

- Check “Show Loop 2” to turn on the second loop.
- Keep the orientation of Loop 2 unchanged and adjust the location of Loop 2 to a point where it has the best geometric coupling with Loop 1 through the magnetic flux linkage (tangential direction of field lines is parallel to the dipole moment direction of a loop). Take a screenshot and paste it below. Remember to include the axis labels.

Task 4: Loop-loop coupling

- Change the orientation of Loop 2, so the dipole moment points to the +x direction.
- Move Loop 2 around to find two locations where (1) Loop 1 and 2 are fully coupled and (2) Loop 1 and Loop 2 are null coupled. Paste the TWO screenshots below. Remember to include the axis labels.

Submission

- If you have Microsoft PowerPoint, you can directly work in em_intro_tasks.pptx (download from the course website)
- You can also choose to copy the contents in the pptx file to your preferred word processing software and work in it
- Or send an email including your answers in plain text and pictures as attachment
- Each team needs to send a document or an email to yangdikun@gmail.com
- Submissions will be reviewed next week