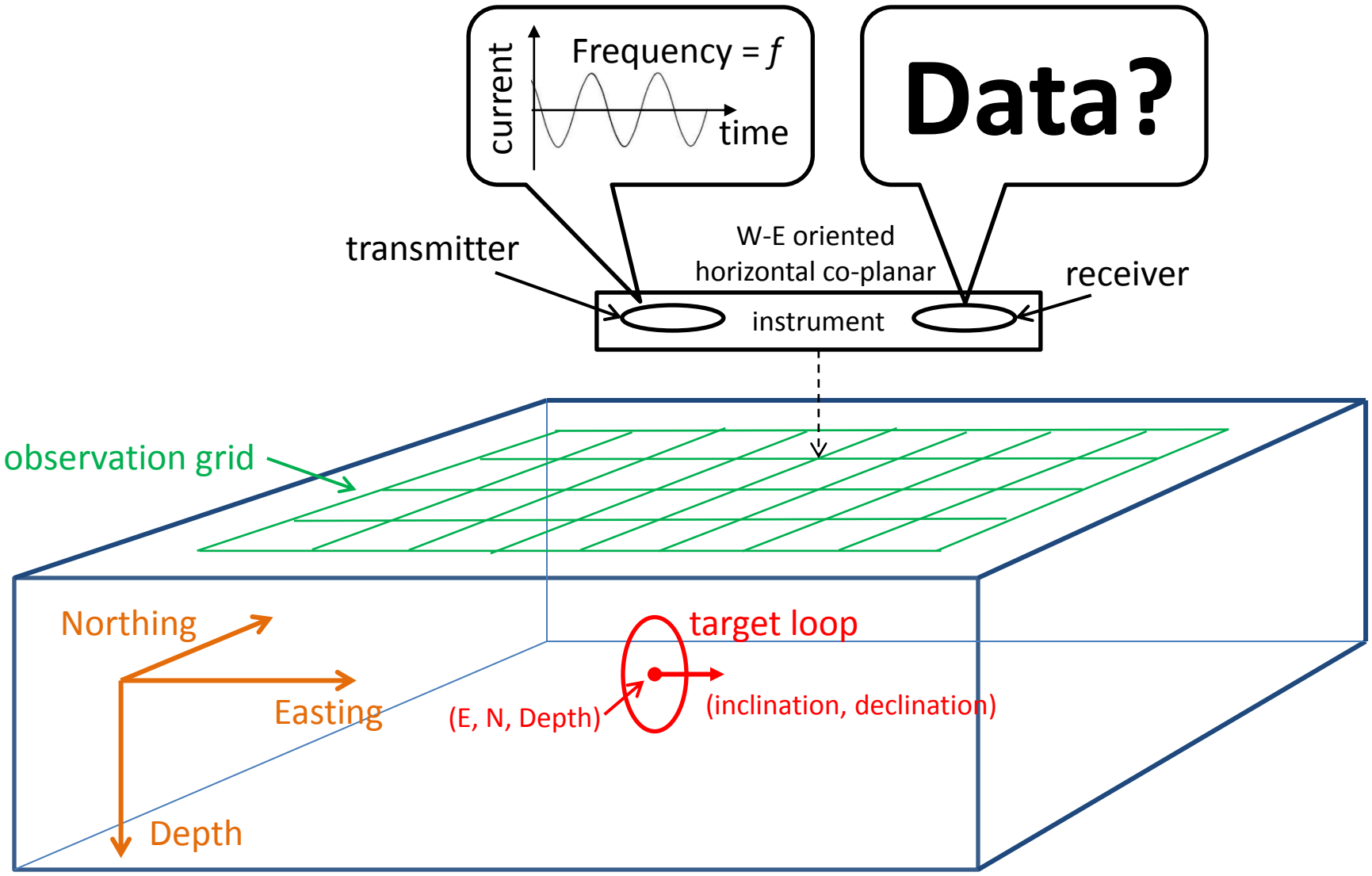
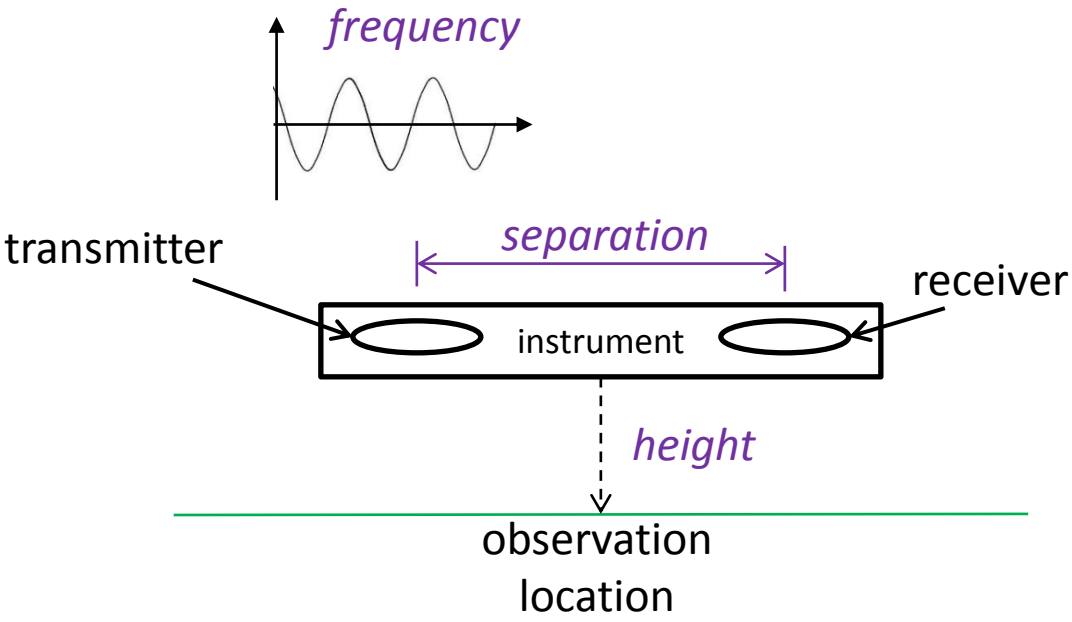
EOSC350 EM Lab: Three-loop Modeling (fem3loop.m)



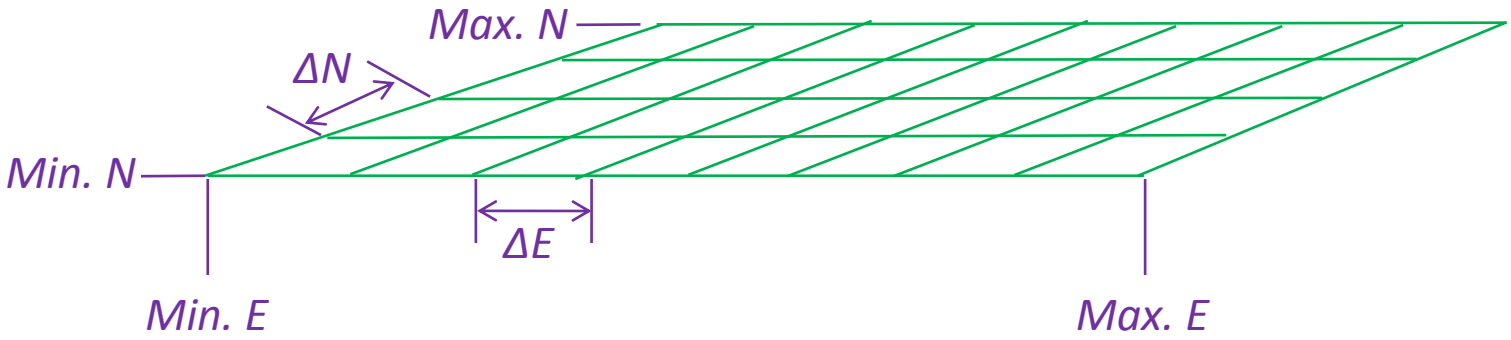
Nov 2011

EOSC350 EM Lab: User-Controlled Variables

Instrument



Observation Grid

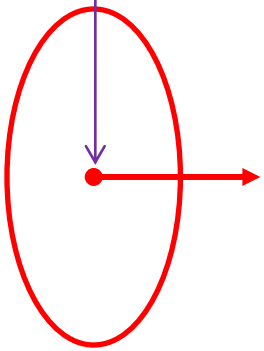


EOSC350 EM Lab: User-Controlled Variables

Target Loop

horizontal coordinates
(easting, northing)

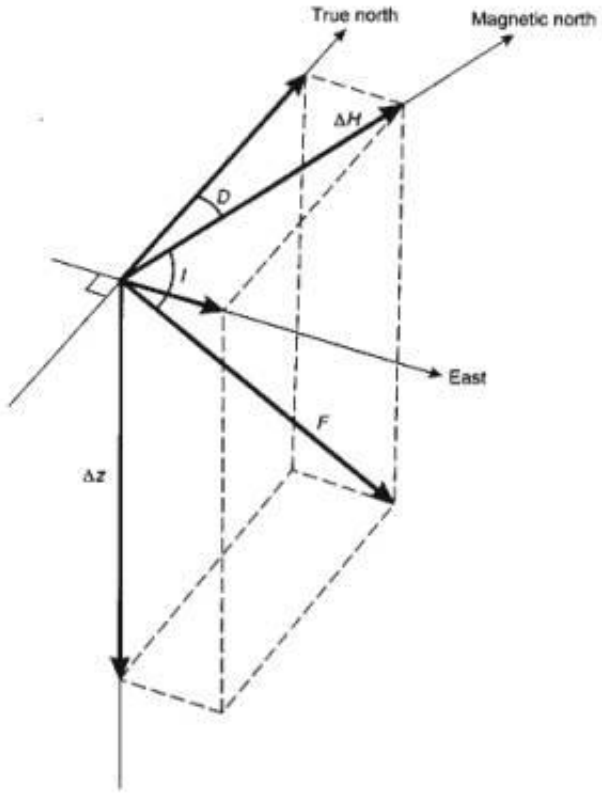
depth



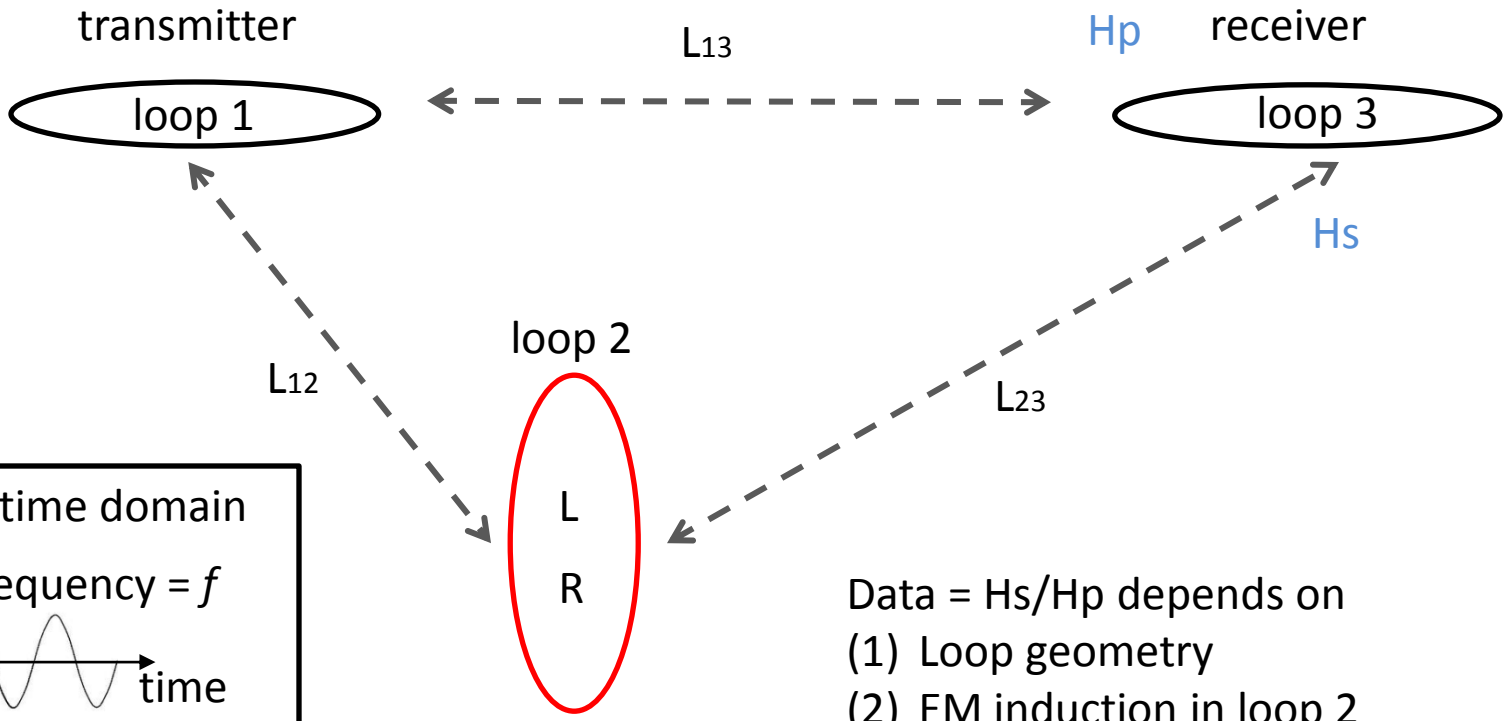
loop properties
- resistance R
- inductance L

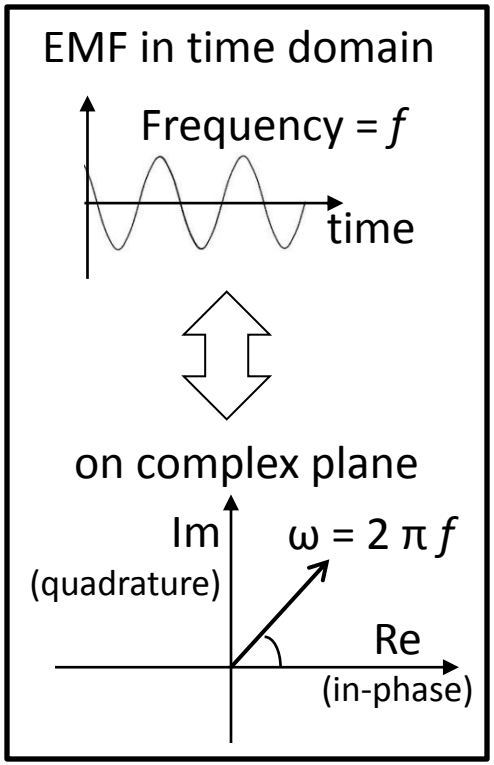
normal direction
(inclination, declination)

- *Similar to geomagnetics*
- *Pointing down inclination > 0*
- *Pointing east declination > 0*



EOSC350 EM Lab





Data = Hs/Hp depends on
(1) Loop geometry
(2) EM induction in loop 2

$$\frac{H_s}{H_p} = -\left(\frac{L_{12}L_{23}}{L\,L_{13}}\right)\left(\frac{\alpha^2 + i\alpha}{1+\alpha^2}\right), \qquad \alpha = \frac{\omega L}{R} = \frac{2\pi f L}{R}$$

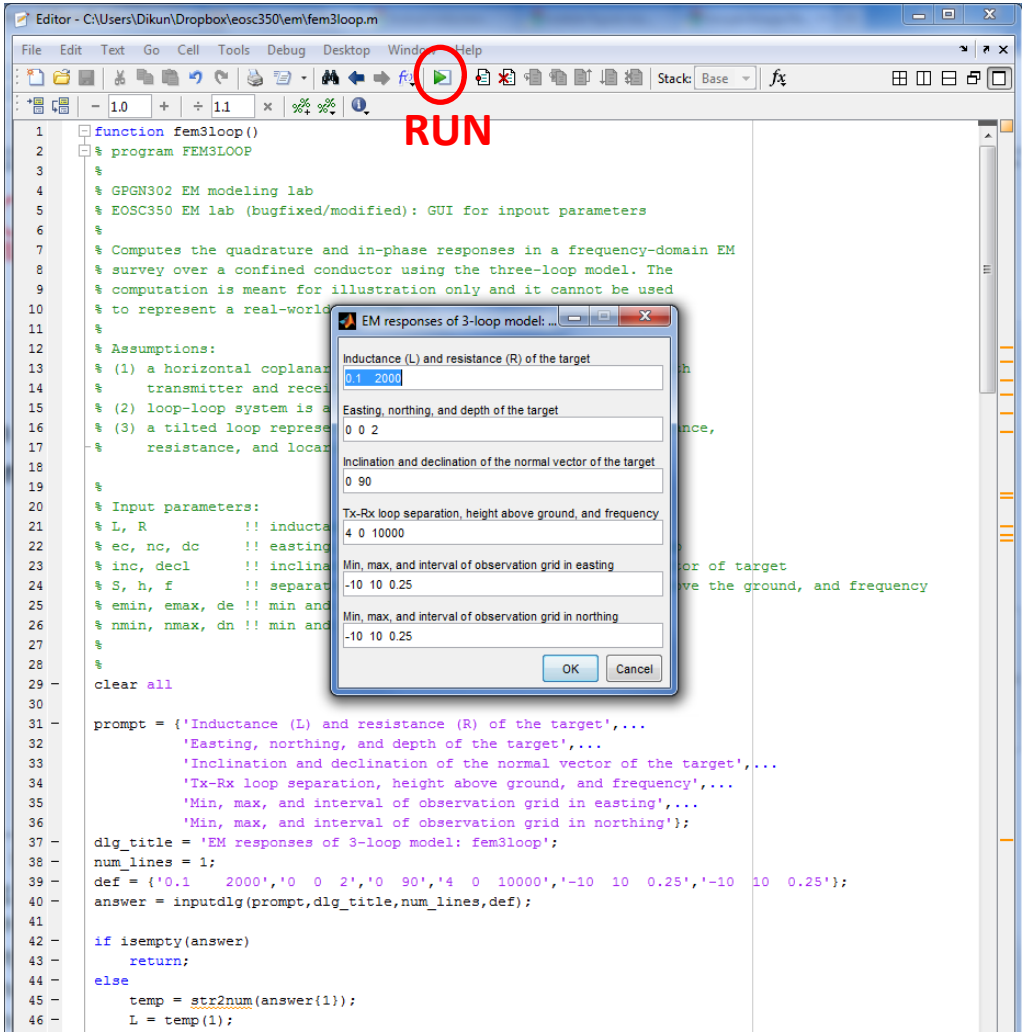
Coupling
- location/orientation
- magnitude of EMF

Induction
- properties of loop 2
- How much in real/imaginary

EOSC350 EM Lab

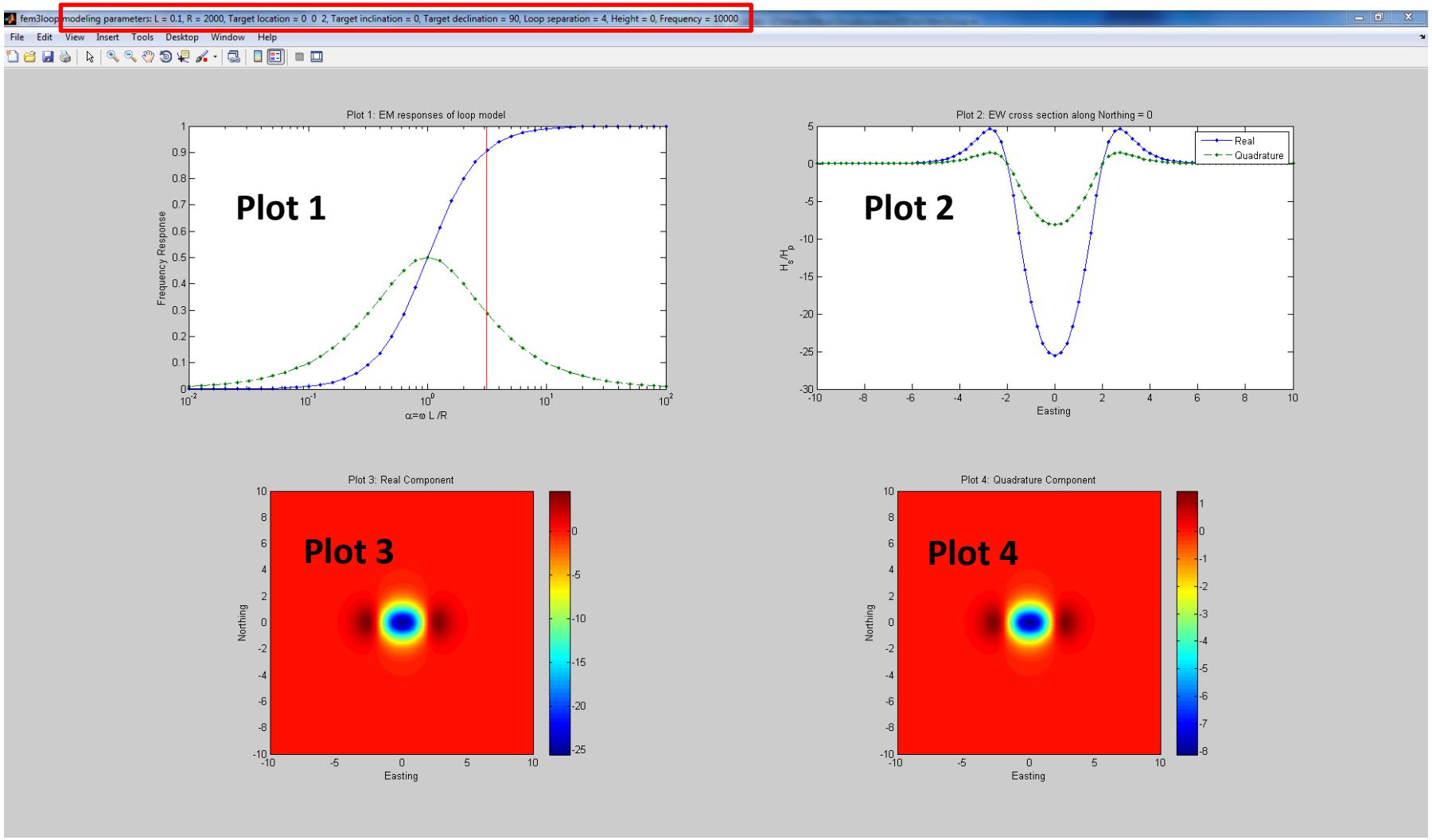
fem3loop.m (Code)

- open it in Matlab
- click  or press F5 to run
- you may be asked to change the current directory of Matlab, choose YES
- input modeling parameters in the input dialog box
- click OK to see the plots and answer the questions

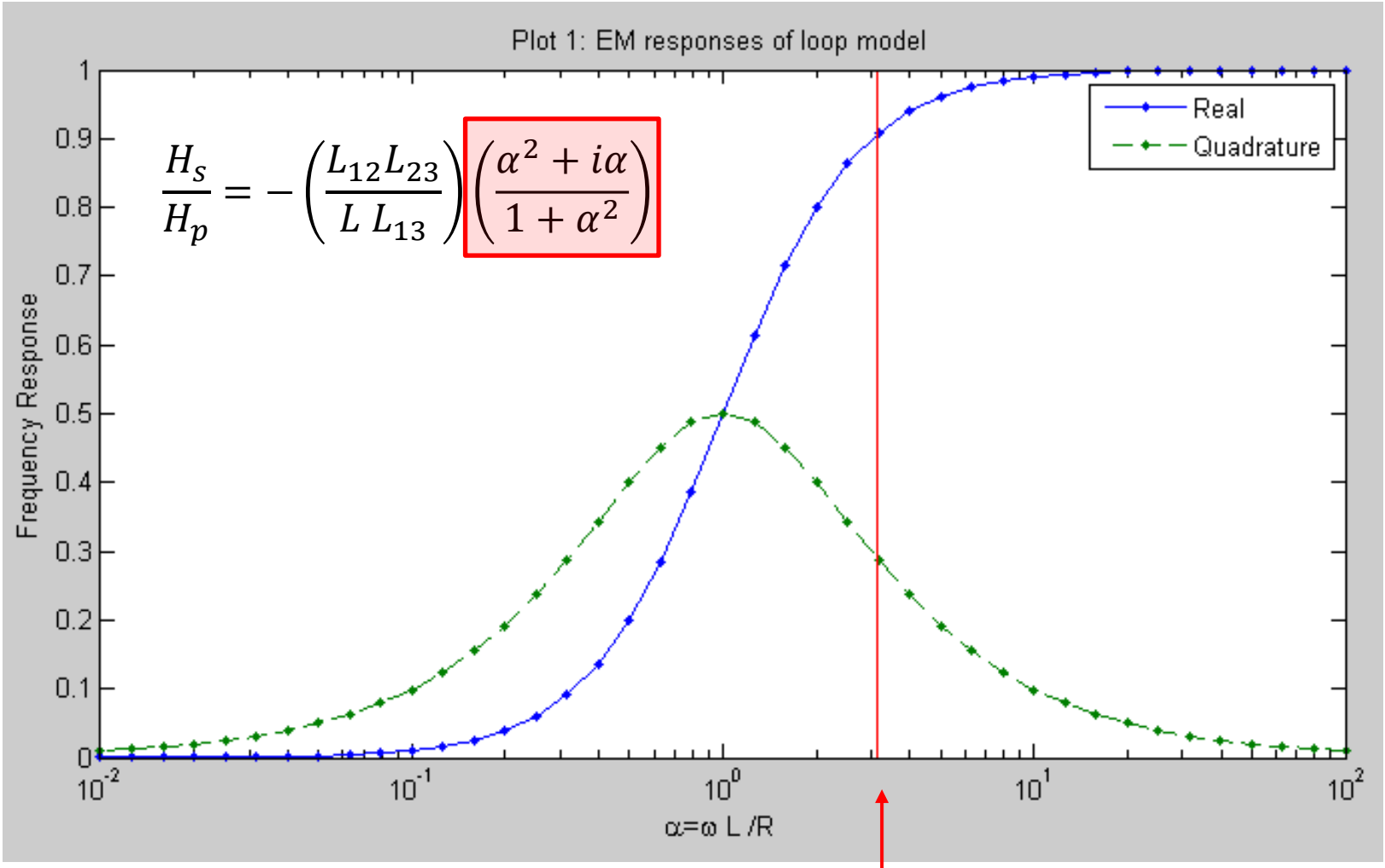


EOSC350 EM Lab: Output Figure – Four Plots

fem3loop modeling parameters



EOSC350 EM Lab: Output Figure – Plot 1

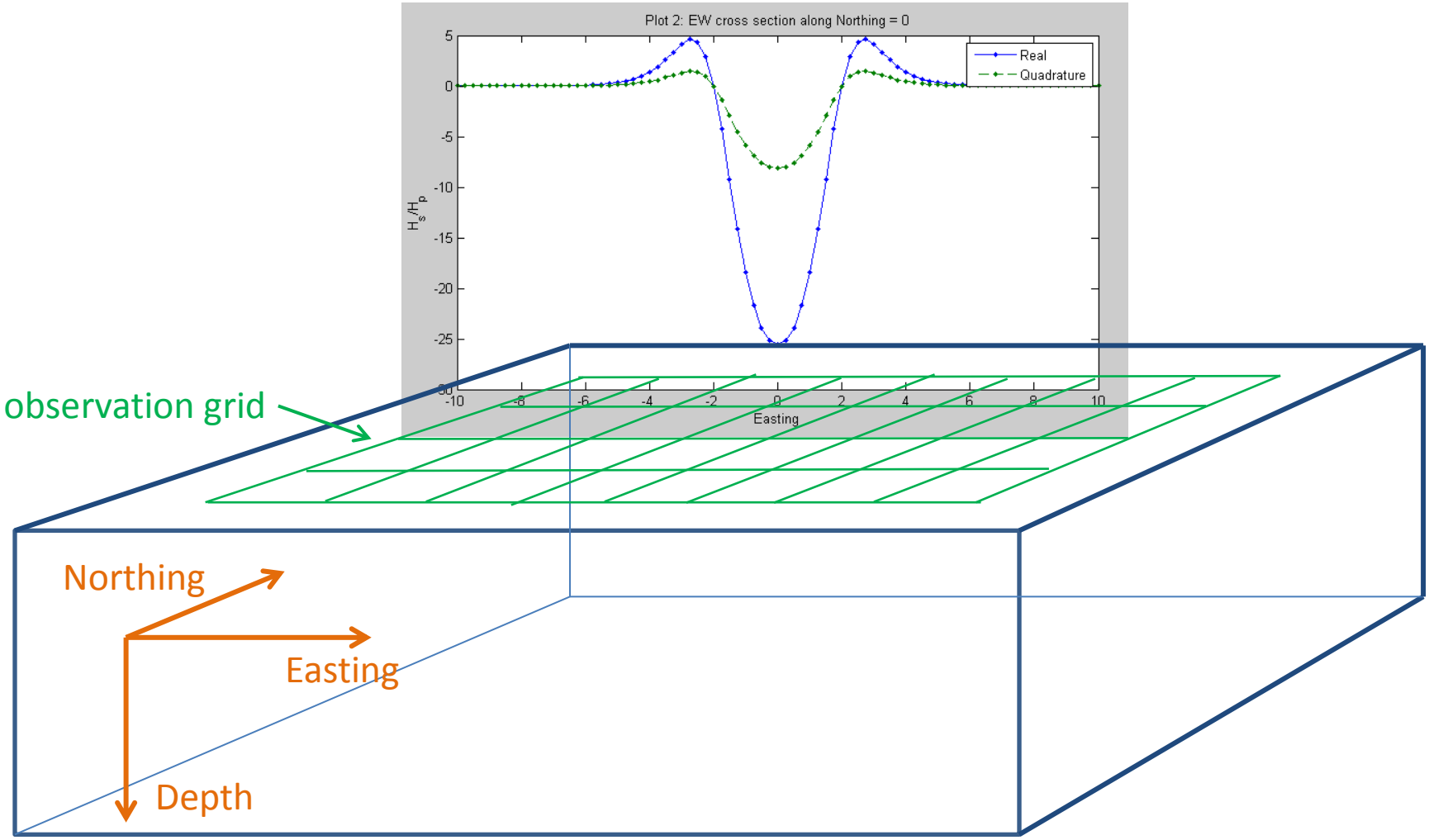


Frequency responses of loop 2 have nothing to do with loop geometry.

determined by input parameters

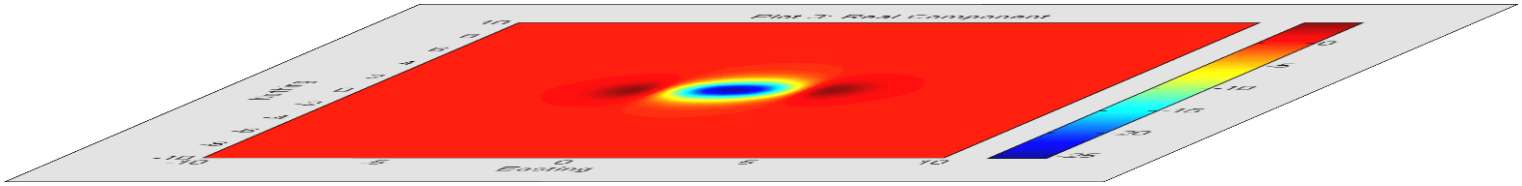
L = 0.1; R = 2000; f = 10000

EOSC350 EM Lab: Output Figure – Plot 2

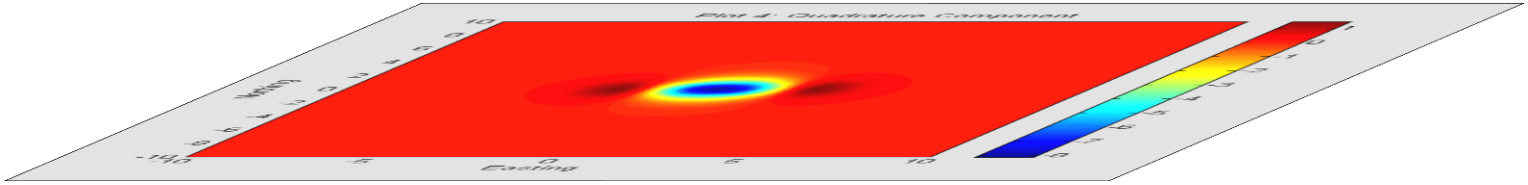


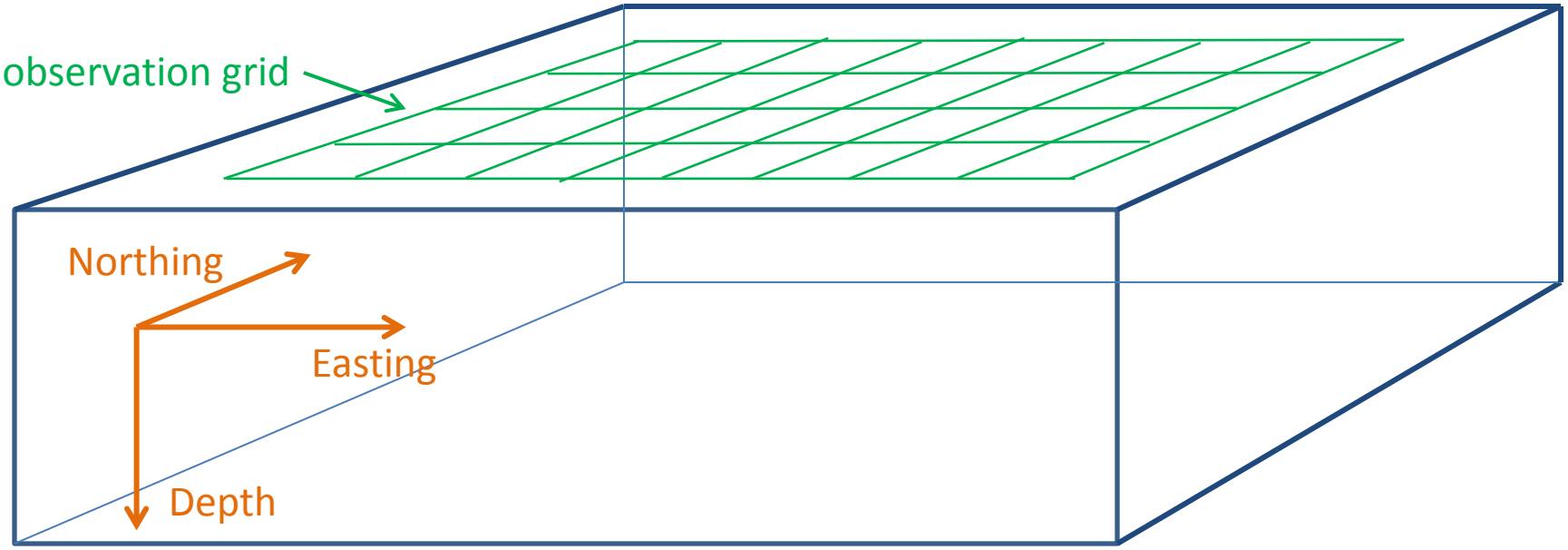
EOSC350 EM Lab: Output Figure – Plot 3 & 4

Plot 3. map of real (in-phase)



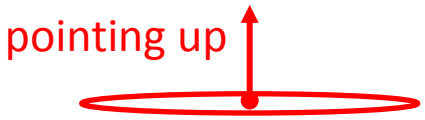
Plot 4. map of imaginary (quadrature)





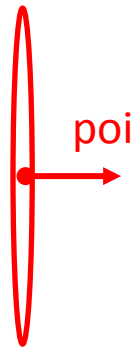
EOSC350 EM Lab: Physics

Orientation of Loop

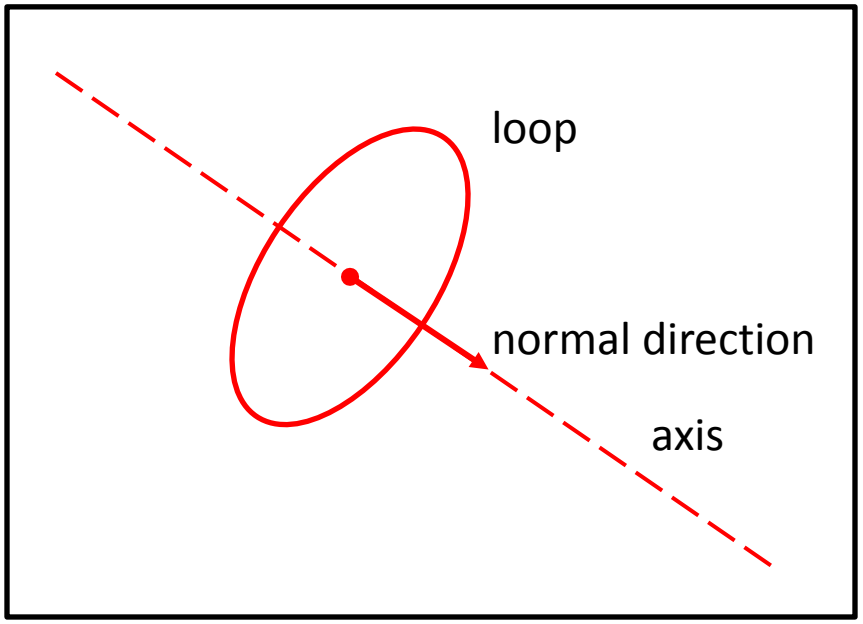


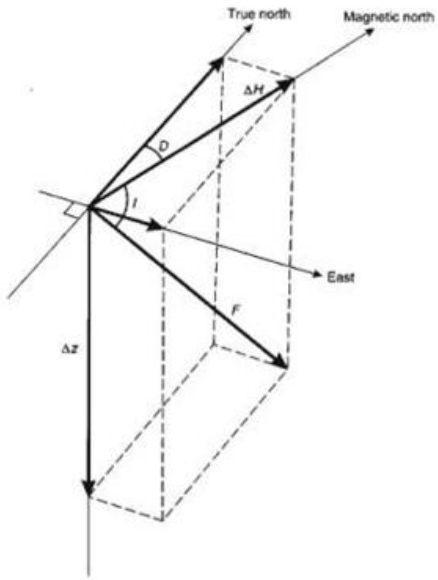
horizontal loop
(vertical dipole)
I = -90, D = 0

vertical loop
(horizontal dipole)
I = 0, D = 0



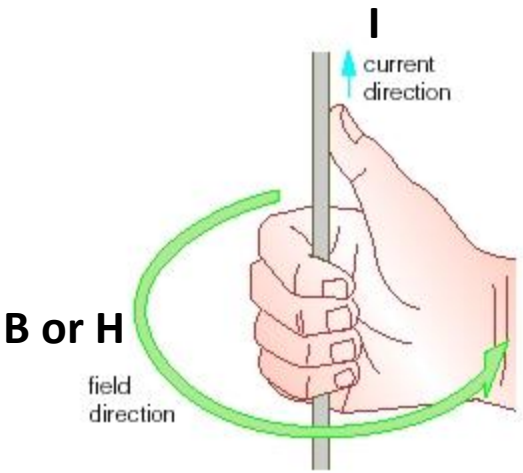
vertical loop
(horizontal dipole)
I = 0, D = 90

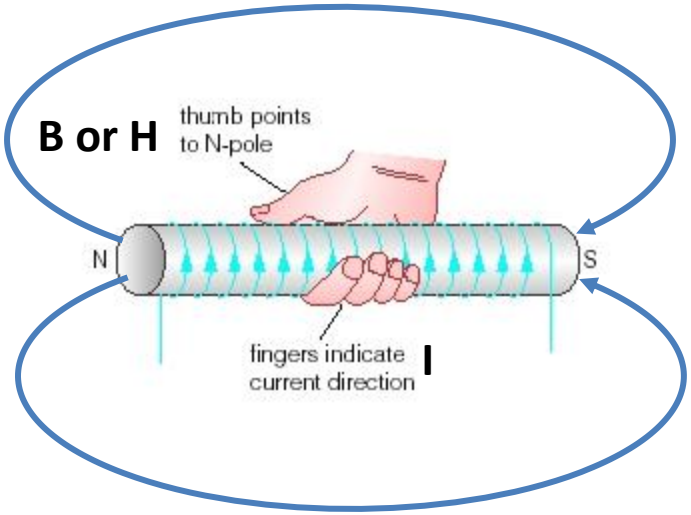




EOSC350 EM Lab: Physics

Right-hand Rule





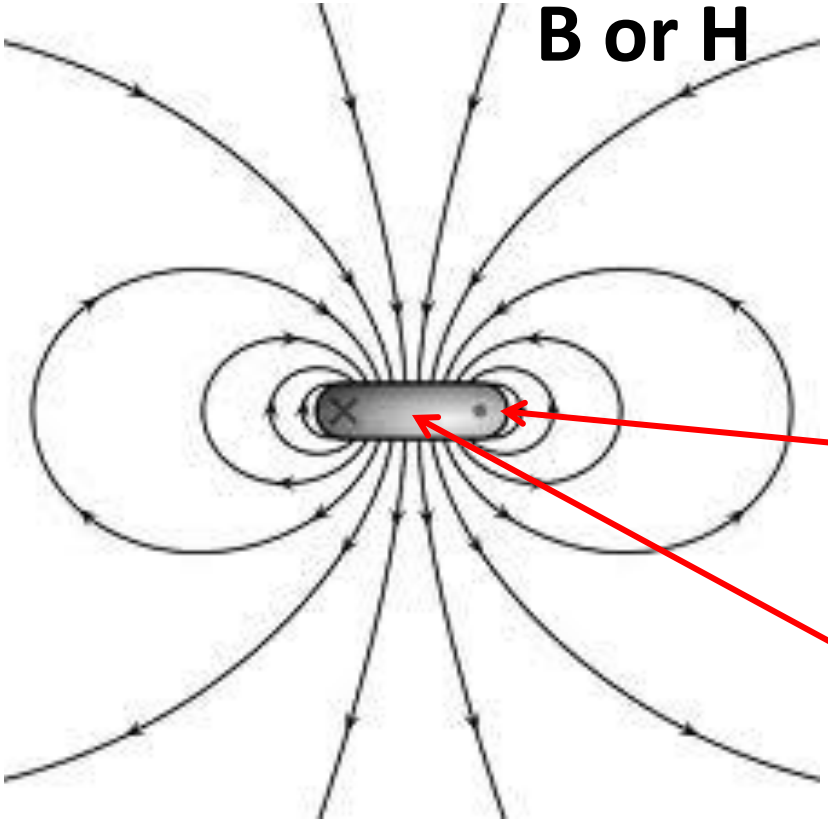
Lenz's Law

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$$

The secondary field counteracts the change of magnetic flux due to the primary field.

EOSC350 EM Lab: Physics

Magnetic Field of Current Loop (Dipole)



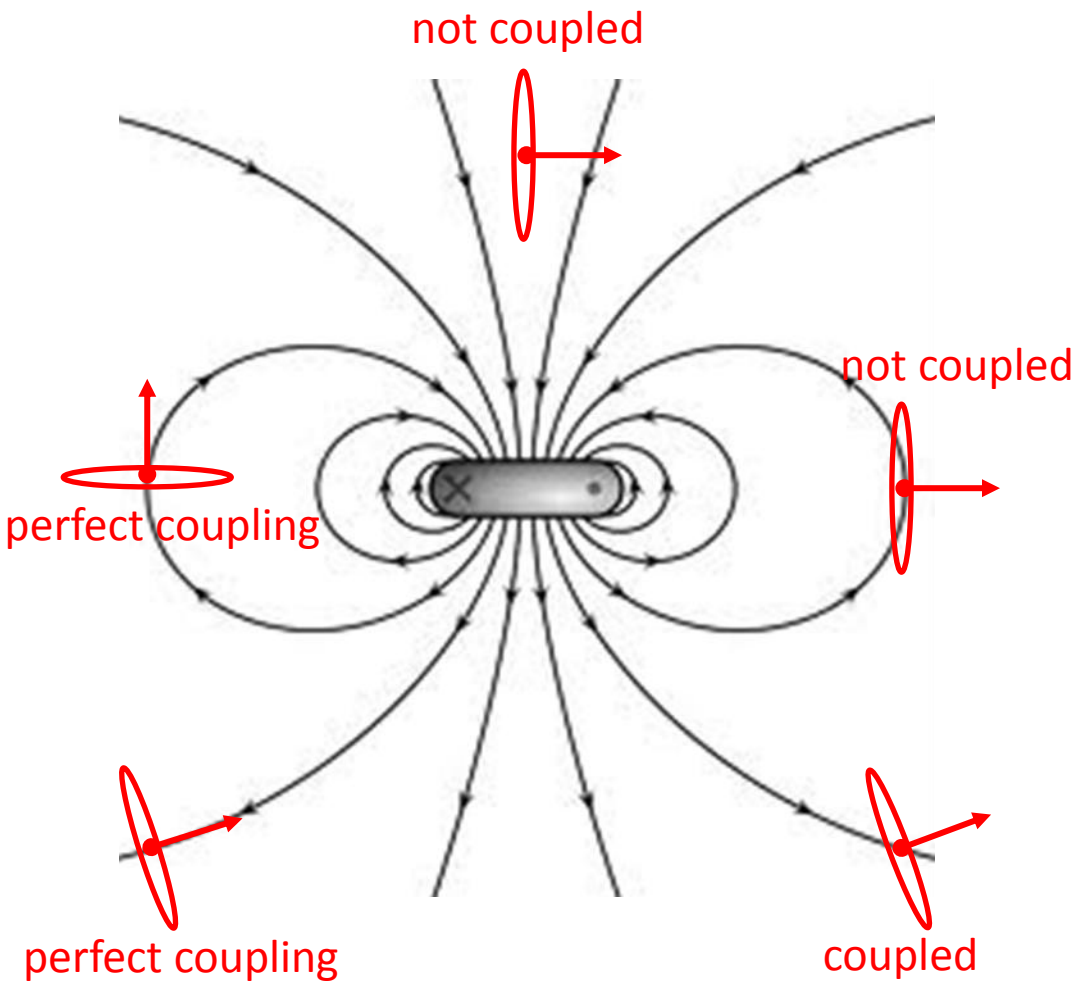
Total strength of B or H at a fixed observation point is proportional to the current in the loop.

Current direction: clockwise

Horizontal loop (vertical normal direction) : inclination = 90, declination = 0.

EOSC350 EM Lab: Physics

Coupling of Loops



Angle between B field vector and normal direction:
Small angle = good coupling
Large angle = bad coupling

Good coupling: more efficient induction

Bad coupling: poor induction or no induction

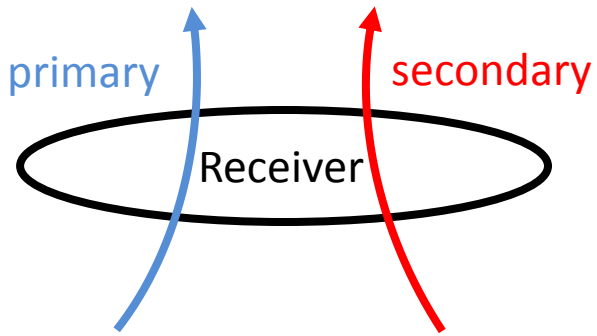
Think about coupling in 3D

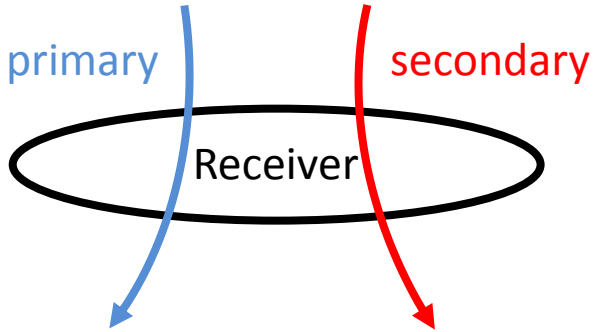
EOSC350 EM Lab: Physics

Sign Convention for the data Hs/Hp

Positive

primary and secondary in same direction





Negative

primary and secondary in opposite directions