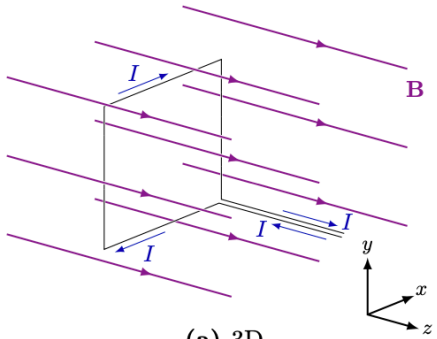
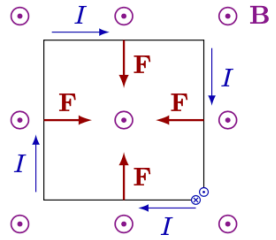
PHY117 HS2023

Week 10, Lecture 2
Nov. 22nd, 2023
Prof. Ben Kilminster



(a) 3D.



(b) 2D in xy plane.

Figure 7.9: Rectangular current loop in an external, uniform magnetic field $\mathbf{B} = B\hat{\mathbf{z}}$.

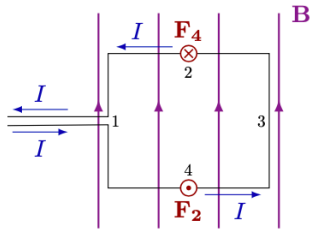
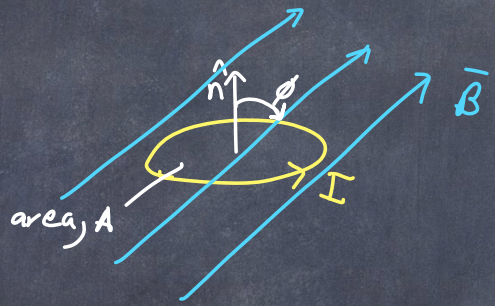
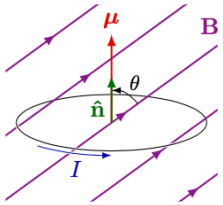
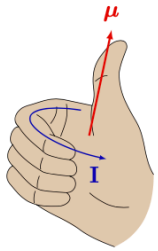


Figure 7.10: Rectangular current loop in an external magnetic field $\mathbf{B}$.


$\hat{n}$
θ
$\vec{B}$
area, A
I



(a) Magnetic moment of a current loop in a uniform magnetic field.



(b) Right-hand rule for the magnetic moment of a current loop.

Figure 7.11: Magnetic moment.

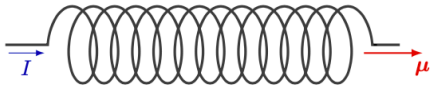
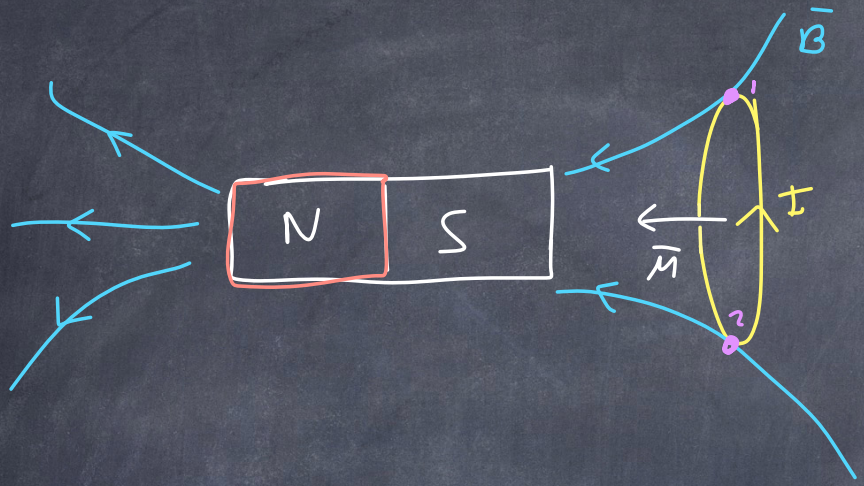
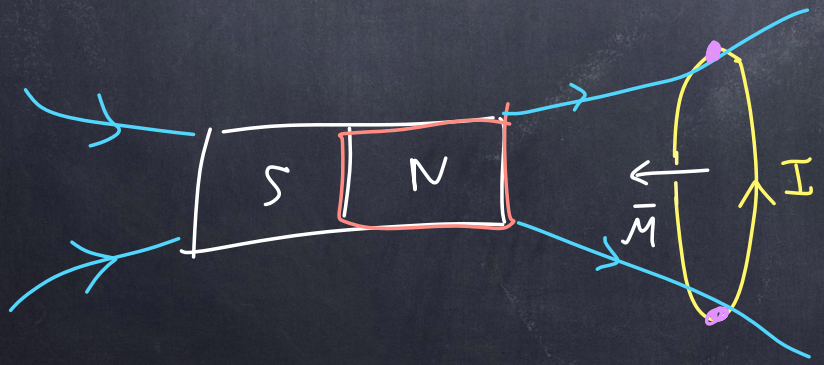
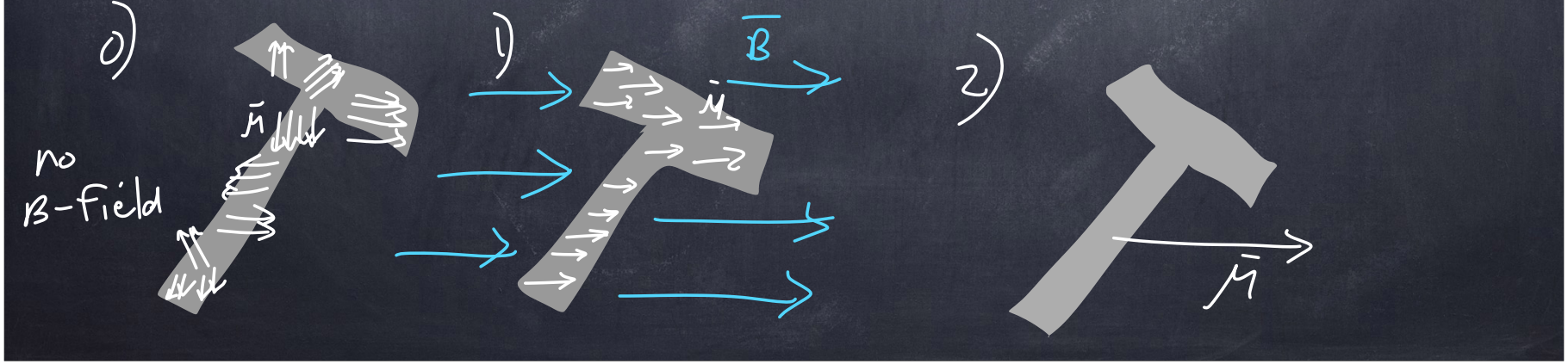


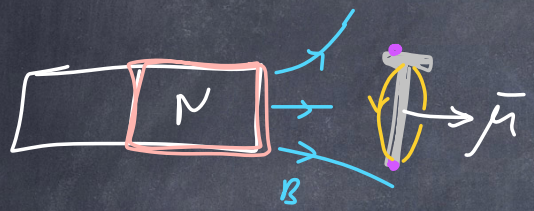
Figure 7.12: Magnetic moment of a solenoid with N windings.

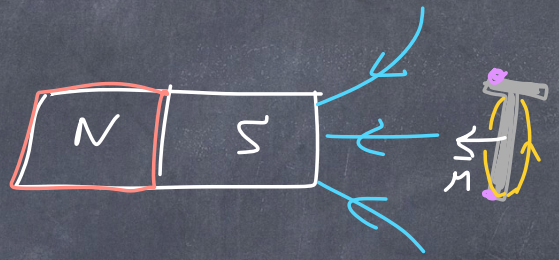
What if the magnetic field is non-uniform?

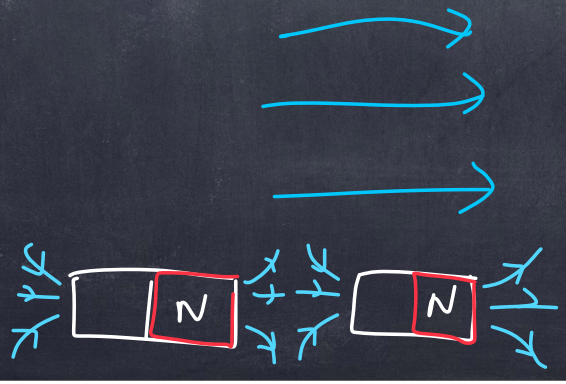




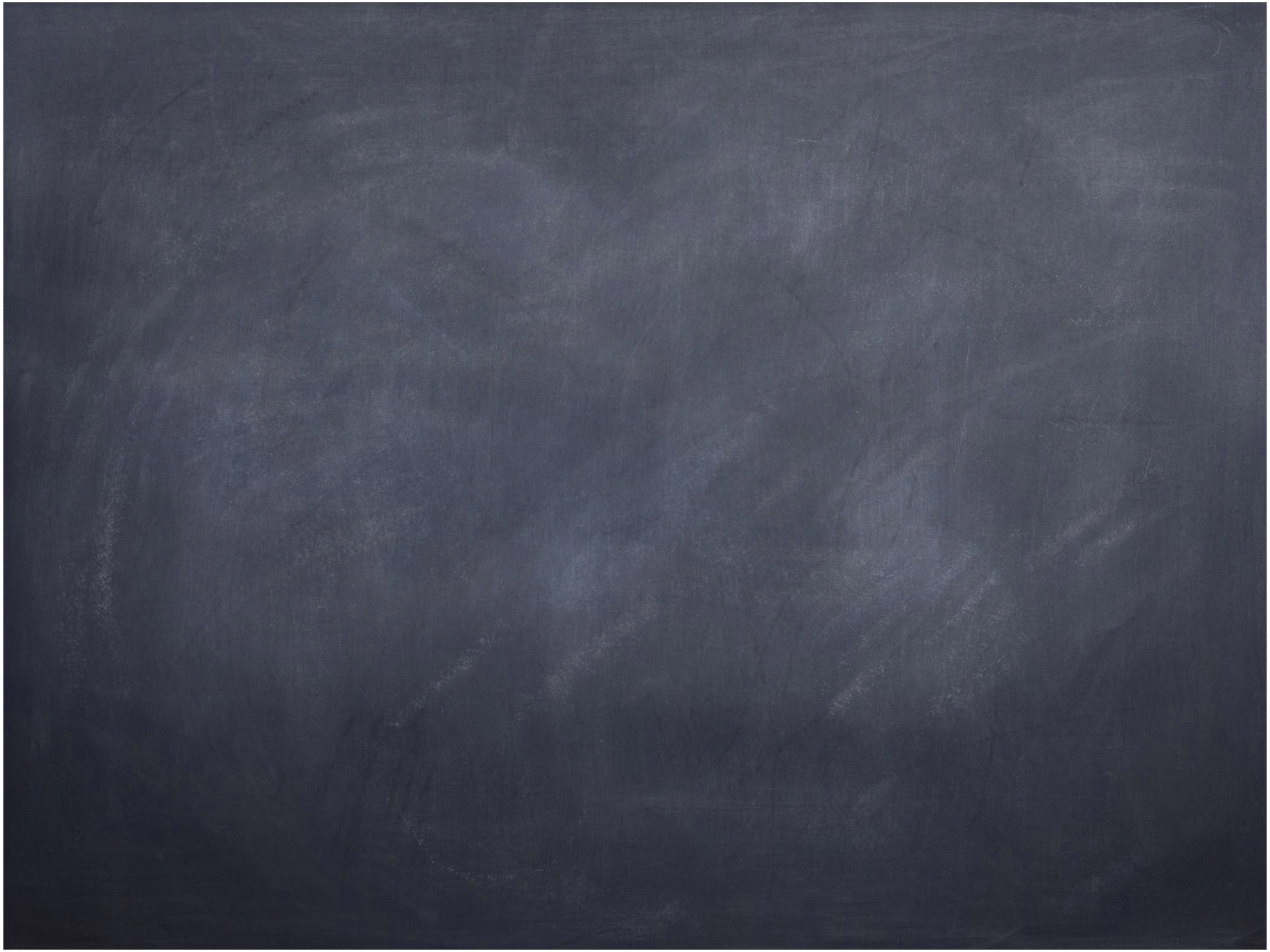

0)
no
B-field
1)
B
2)

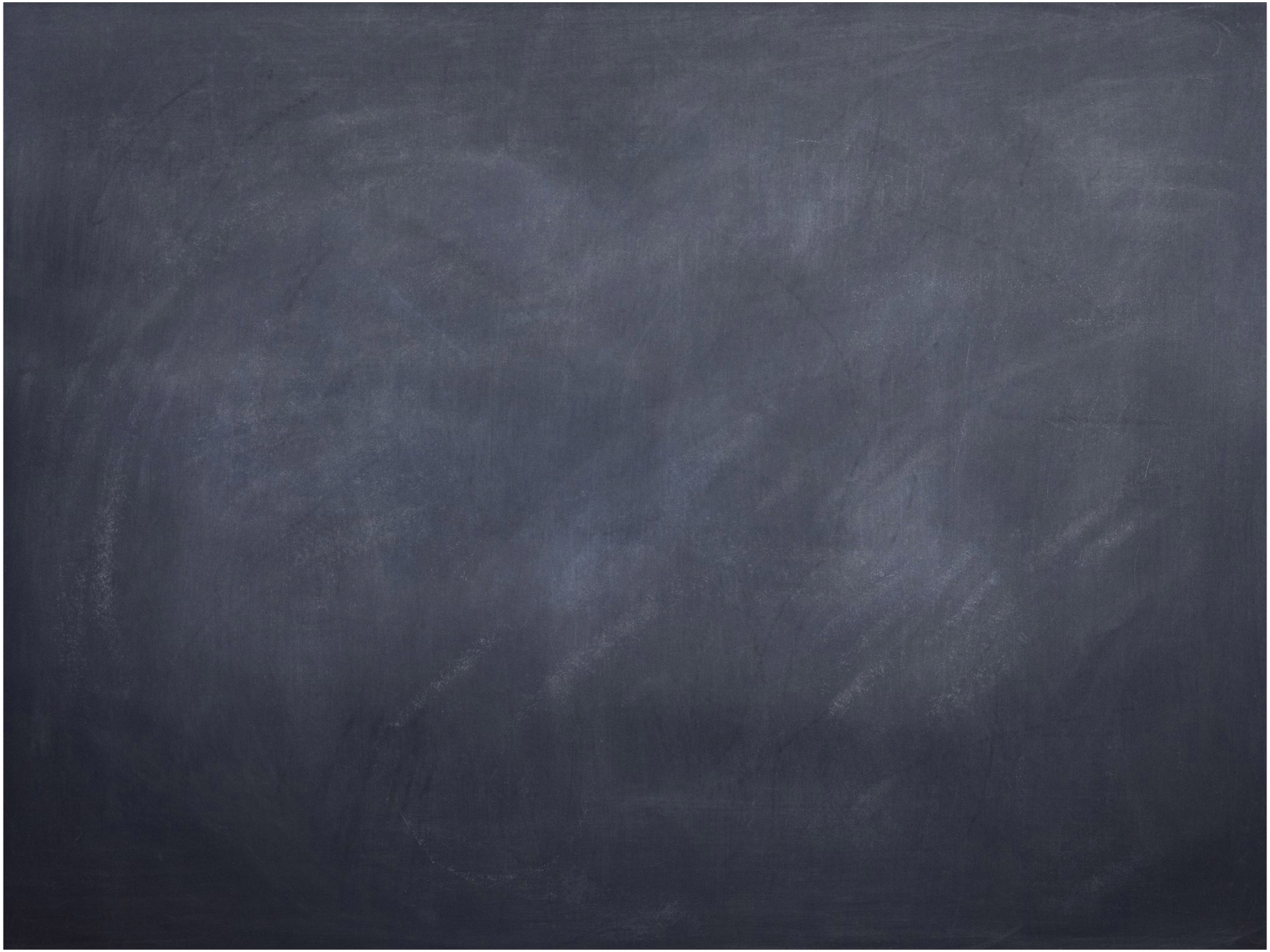

N
B
$\vec{\mu}$

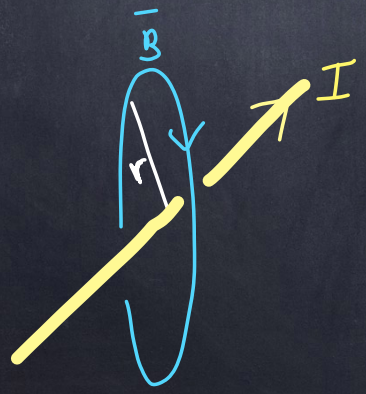

N
S
$\vec{\mu}$

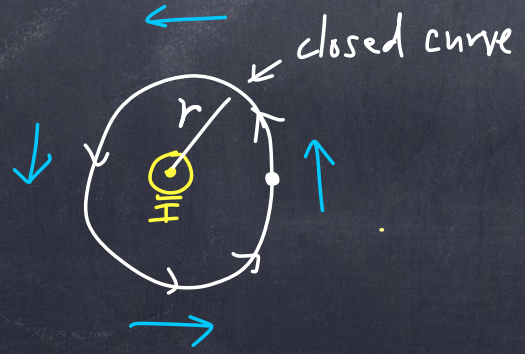

N
N


$\vec{\mu}$

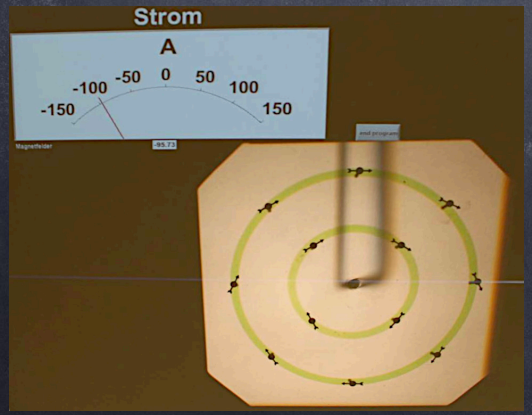








we pick a curve where $\bar{B} \parallel \bar{\ell}$


Strom
A
-150
-100
-50
0
50
100
150

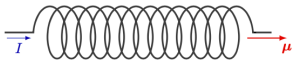
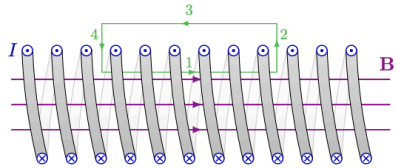
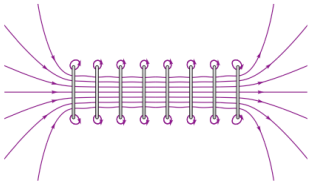


Figure 7.12: Magnetic moment of a solenoid with N windings.

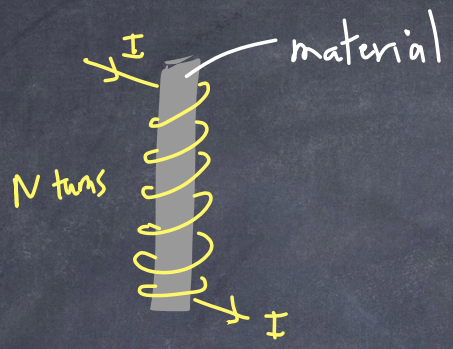


(a) Using Ampère's law on a rectangular loop.

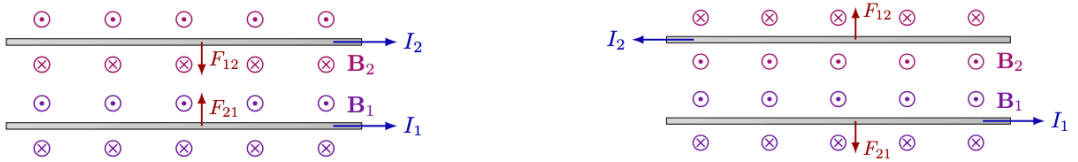


(b) Realistic field of a solenoid.

Figure 8.6: Magnetic field due to a solenoid.

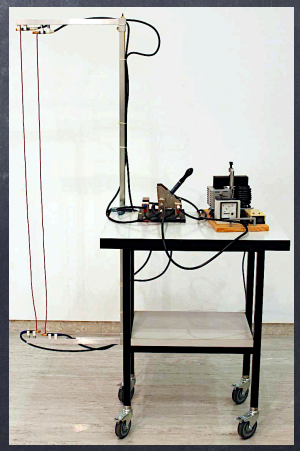


material	$k\left(\frac{\mu}{\mu_0}\right)$
air	1.000 000 37
water	0.999 99 2
copper	0.999 994
pure iron (99.95%)	200 000
iron 99.8%	5000

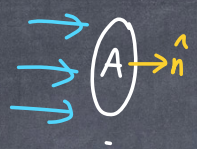


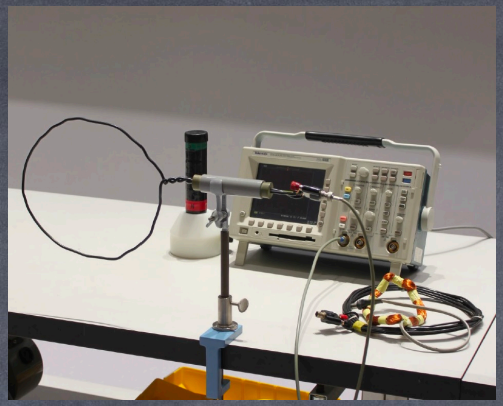
(a) Parallel current. **(b)** Anti-parallel current.

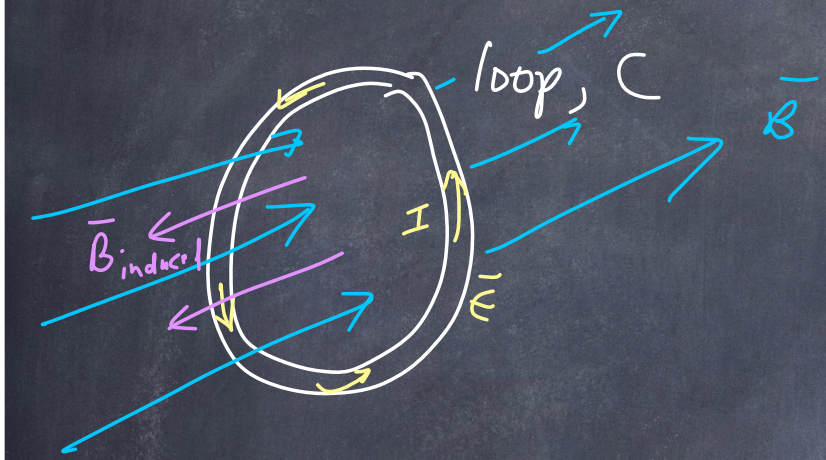
Figure 8.7: Magnetic force between current-carrying wires.

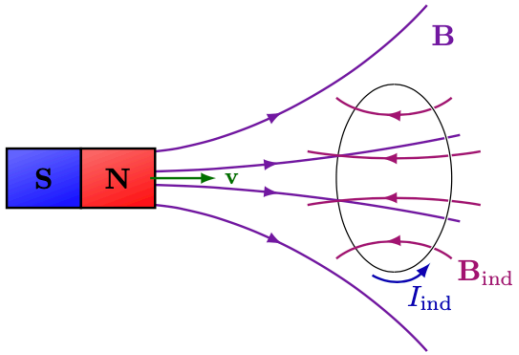


Magnetic flux :

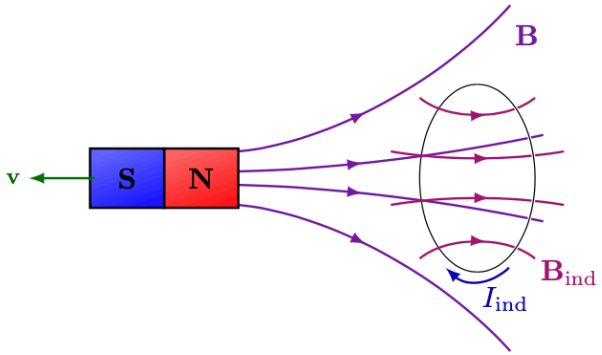





loop, C
$\vec{B}$
$\vec{B}_{induced}$
I
$\vec{\mathcal{E}}$

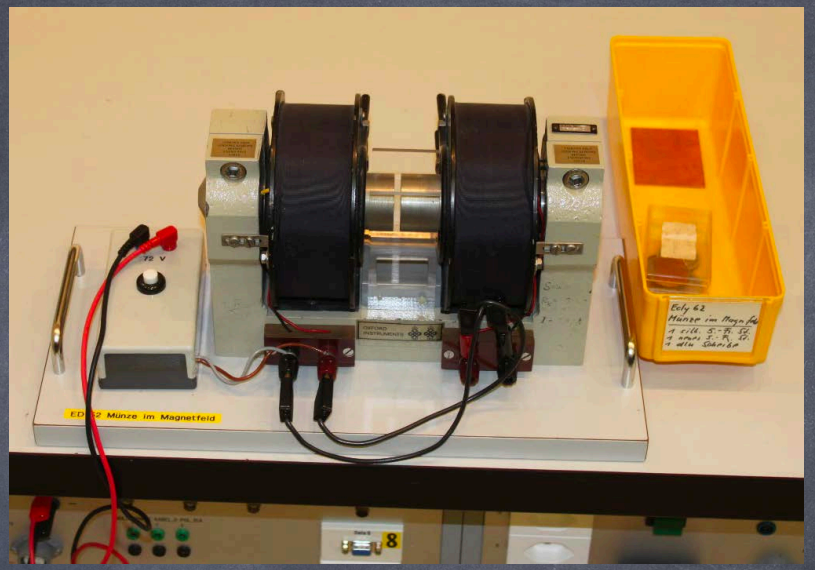


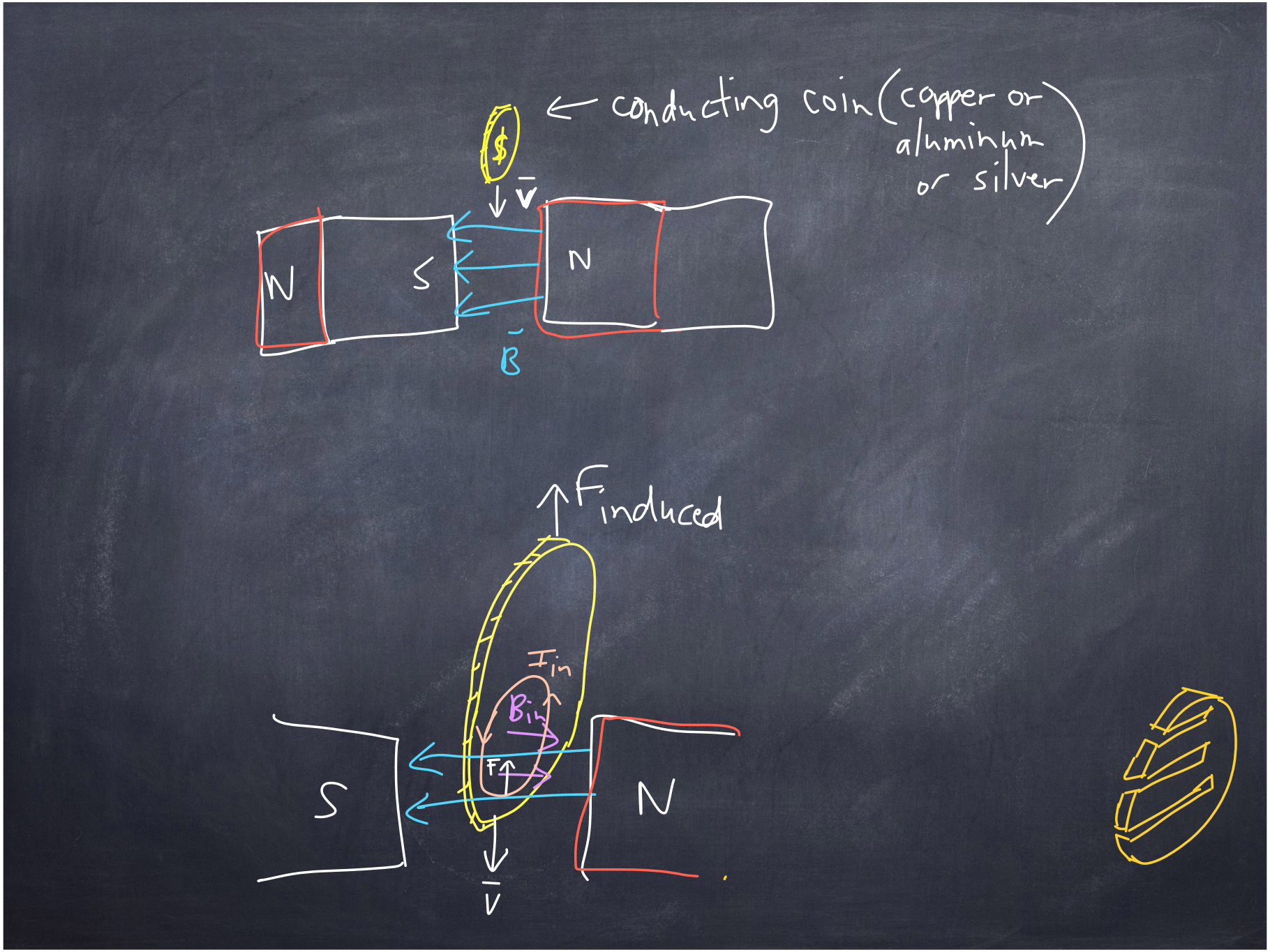
(a) Field moving toward the loop.

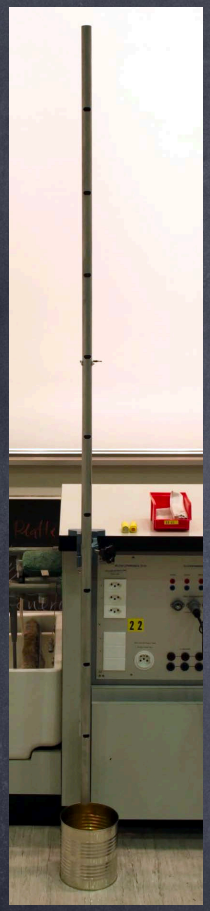


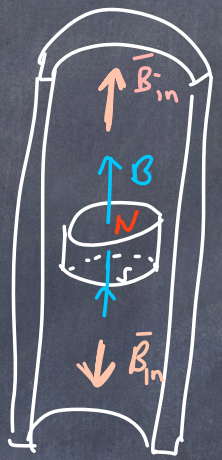
(b) Field moving away from the loop.

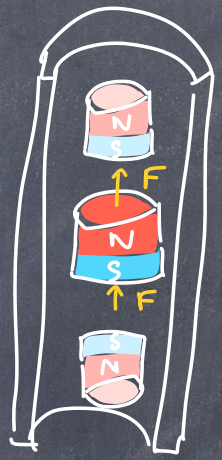
Figure 8.8: The magnetic field $\mathbf{B}$ of a moving bar magnet will induce a current I_{ind} in a conducting loop and therefore a magnetic field $\mathbf{B}_{\text{ind}}$.

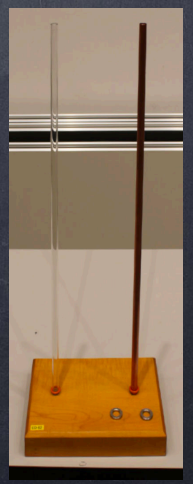

Münze im Magnetfeld

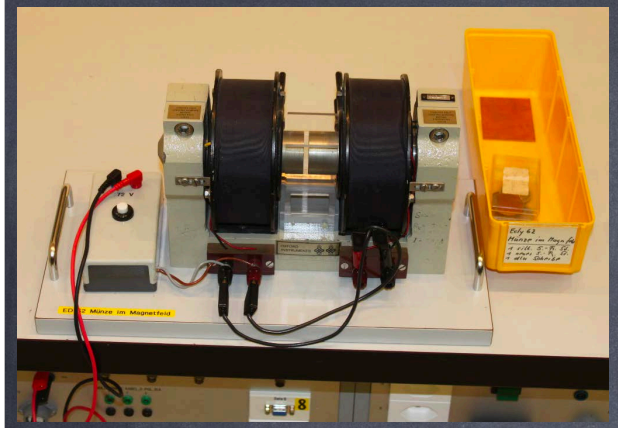

conducting coin (copper or aluminum or silver)
$
v
N
S
N
B
F induced
I in
B in
F
S
N
v

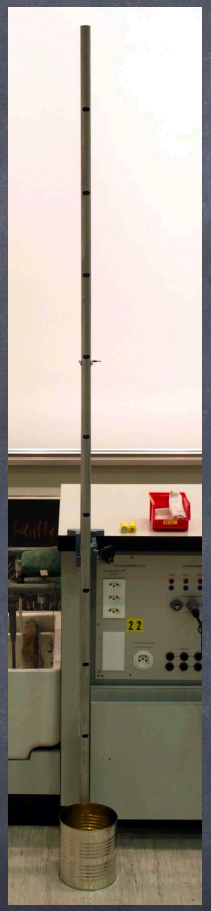



$\bar{B}_{in}$
B
N
$\bar{B}_{in}$


N
S
F
N
S
F
S
N







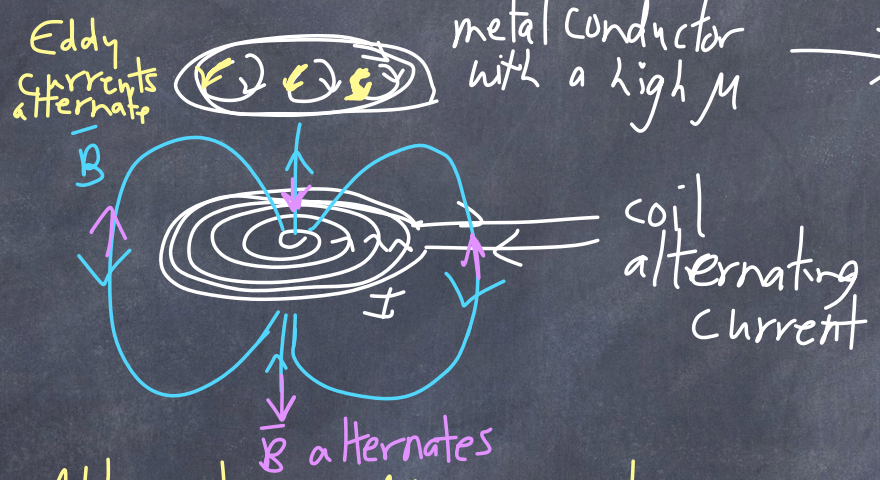
Summary of magnetic field concepts:

1) A moving electric charge may feel a force from a magnetic field.

2) A moving electric charge generates its own magnetic field. (A changing electric field produces a magnetic field.)

3) A changing magnetic field generates electric currents that produce an opposing magnetic field.

Induction stove uses Eddy currents:

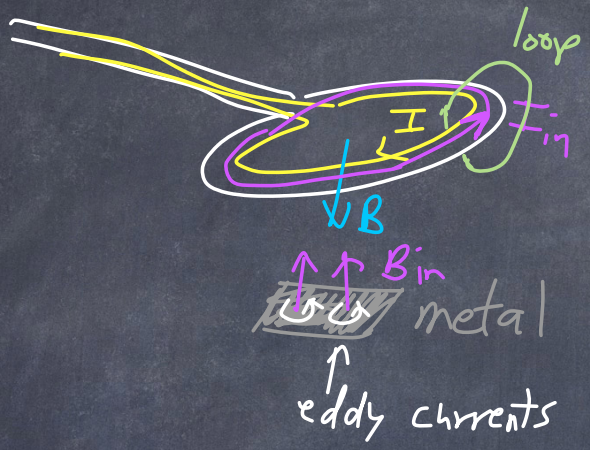


metal conductor with a high μ → movement of I generates heat.

coil alternating current

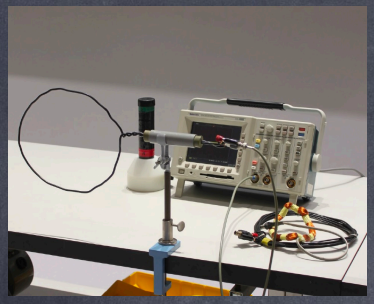
Alternating eddy currents generate heat in a conductor (Joule heating)

Metal detector uses Eddy currents

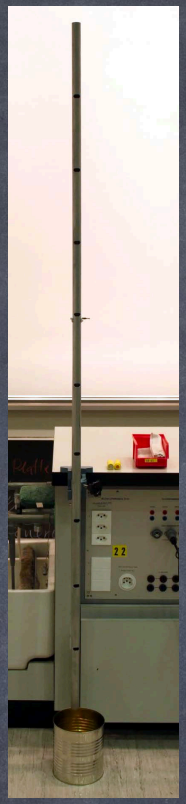


I_{in} is generated in opposite direction, tends to decrease current in metal detector.

Metal detector searches for currents in opposite directions.

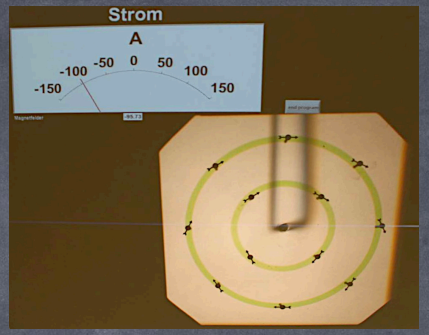


ED48

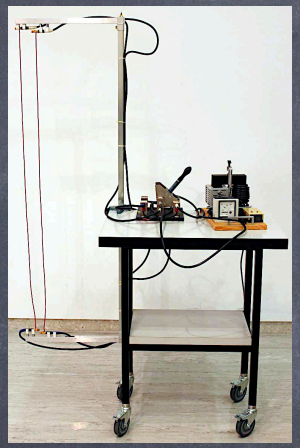


ED63

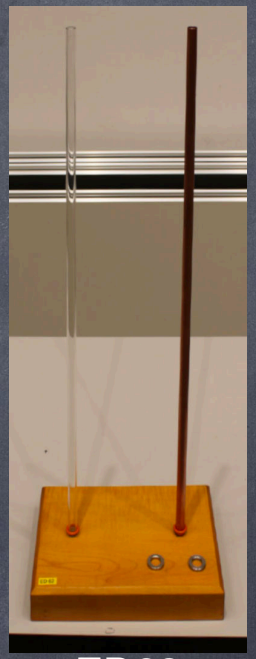
ED6



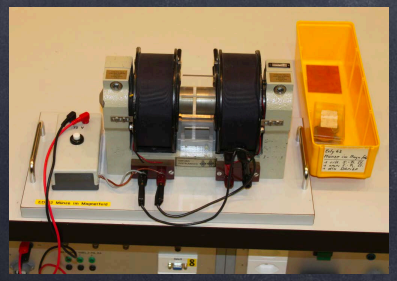
ED10



ED14



ED62



ED61

ED66