Units, fields, moments and forces

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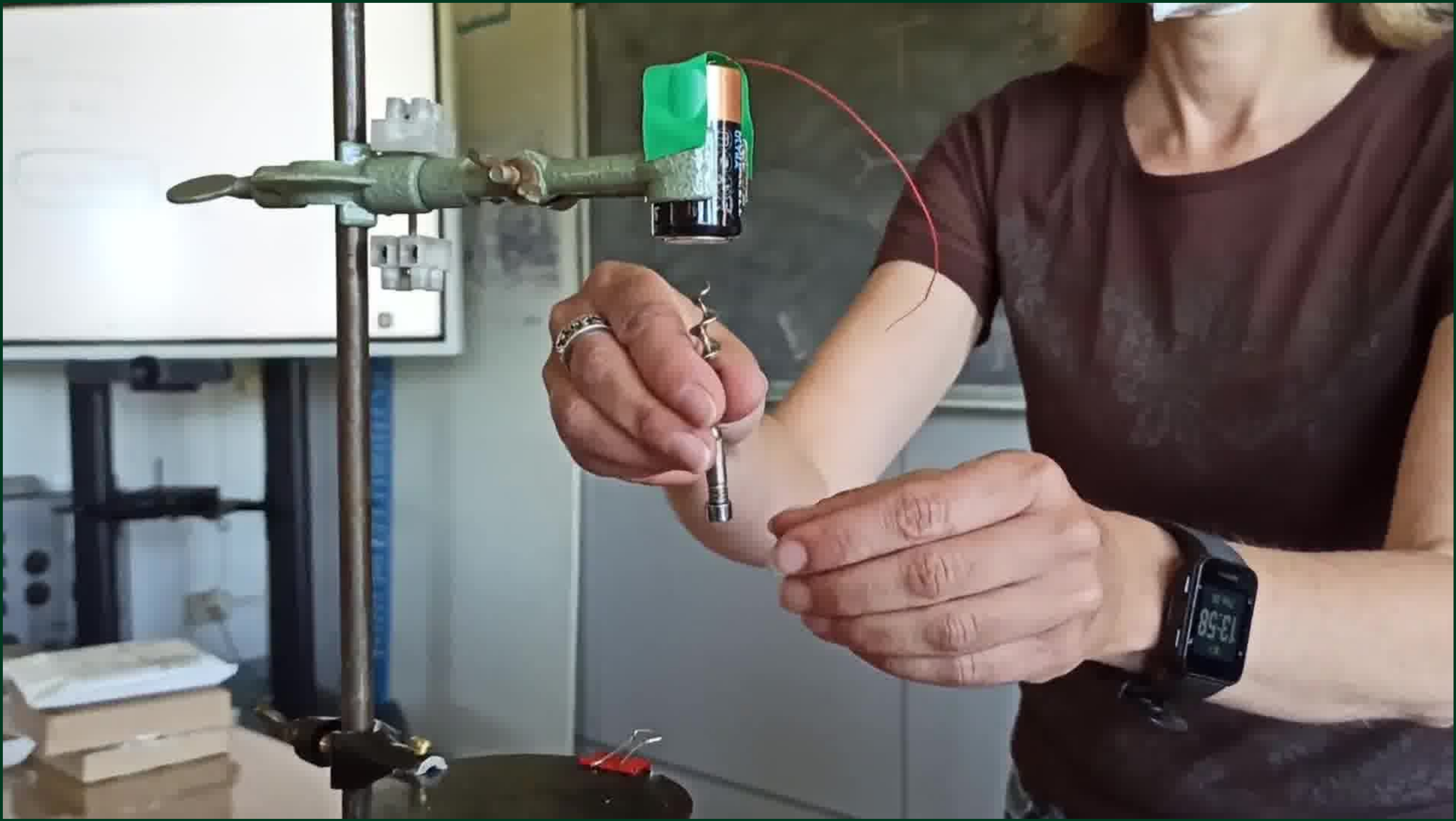
The corkscreew



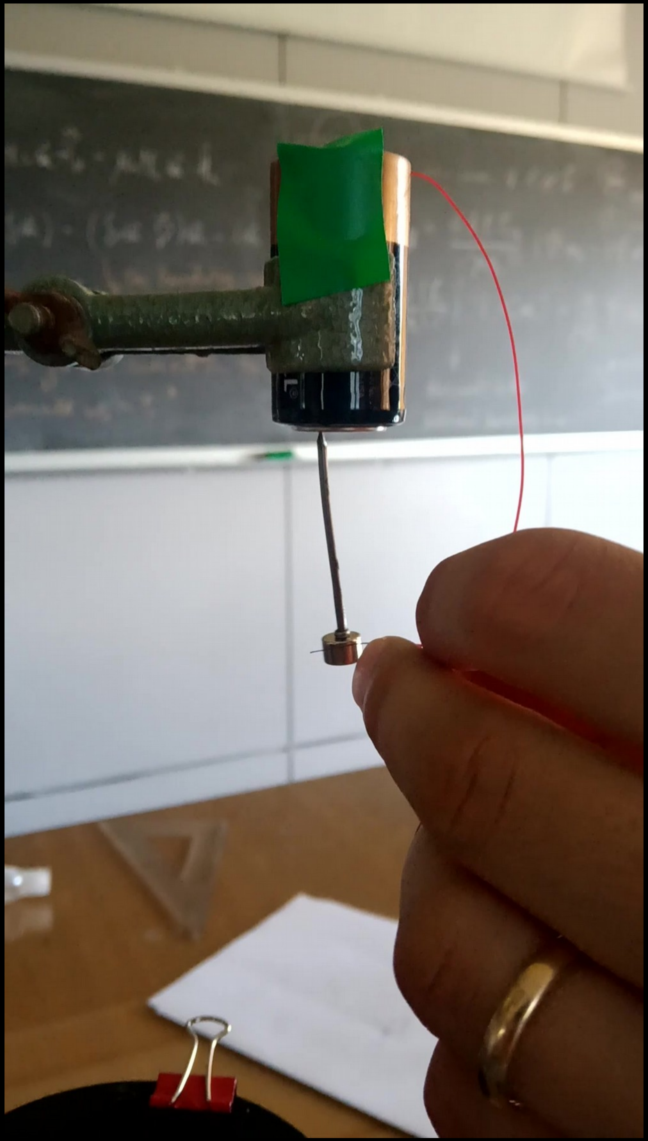
Your guess

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5

Your questions

- QGroup 1
- QGroup 2
- QGroup 3
- QGroup 4
- QGroup 5

See this...



I) Force between two magnets

The energy of a dipole μ in a field B is:

$$\mathcal{E} = -\boldsymbol{\mu} \cdot \boldsymbol{B}$$

If B is coming from a magnet, the force between them is:

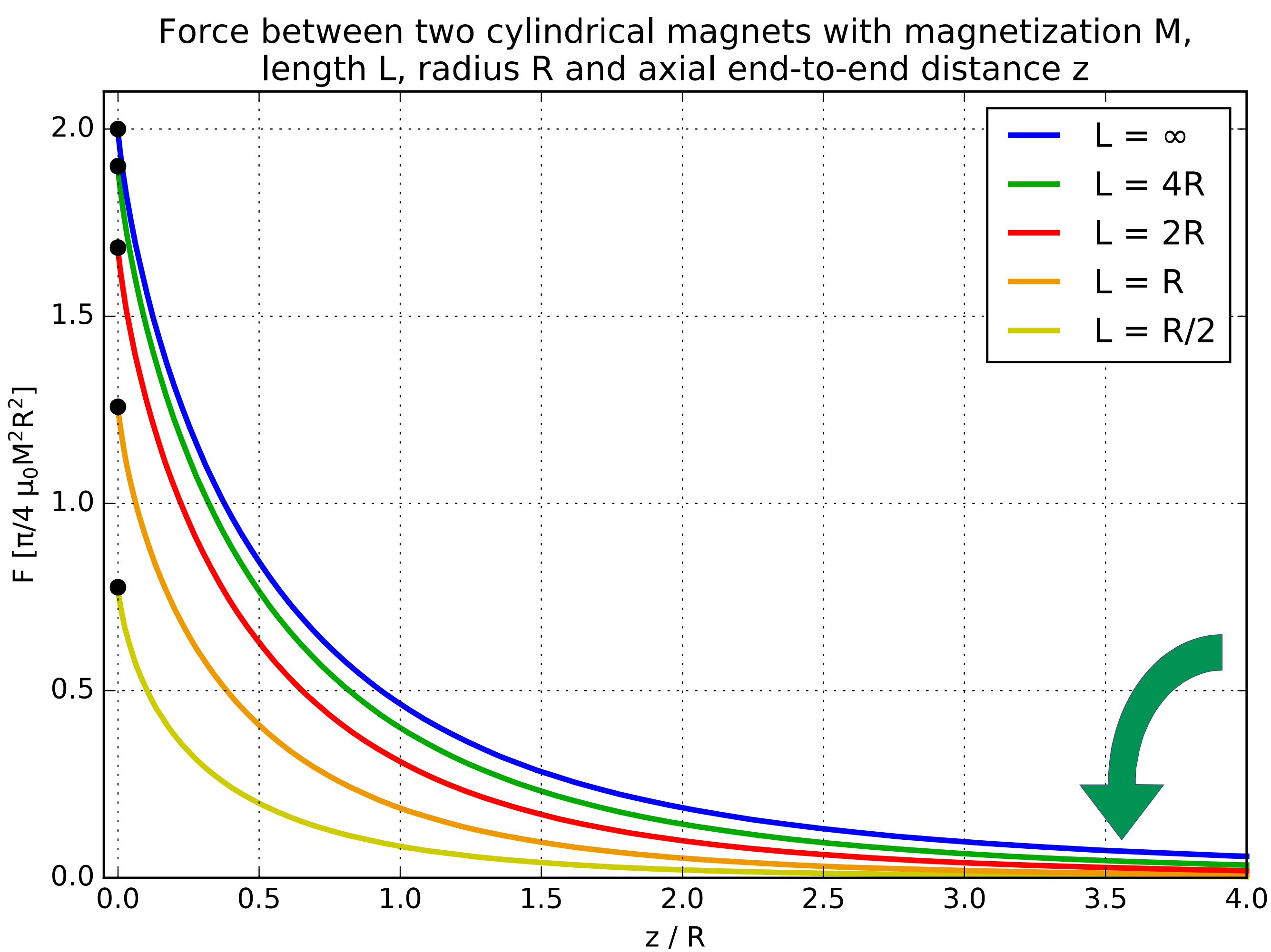
$$\boldsymbol{F} = -\nabla \mathcal{E} = \boldsymbol{\mu} \cdot \nabla \boldsymbol{B}$$

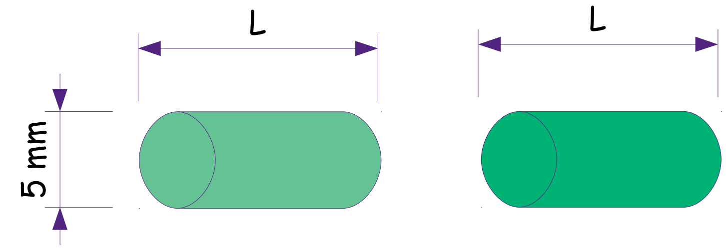
With quite a good approximation, for a magnet of moment $\boldsymbol{m}$

$$\boldsymbol{F} = \boldsymbol{m}_1 \cdot \nabla \boldsymbol{B}_2 = \boldsymbol{m}_2 \cdot \nabla \boldsymbol{B}_1$$

(meaning that the force that 1 makes on 2 is the same that 2 makes on 1)

I) Force between two magnets





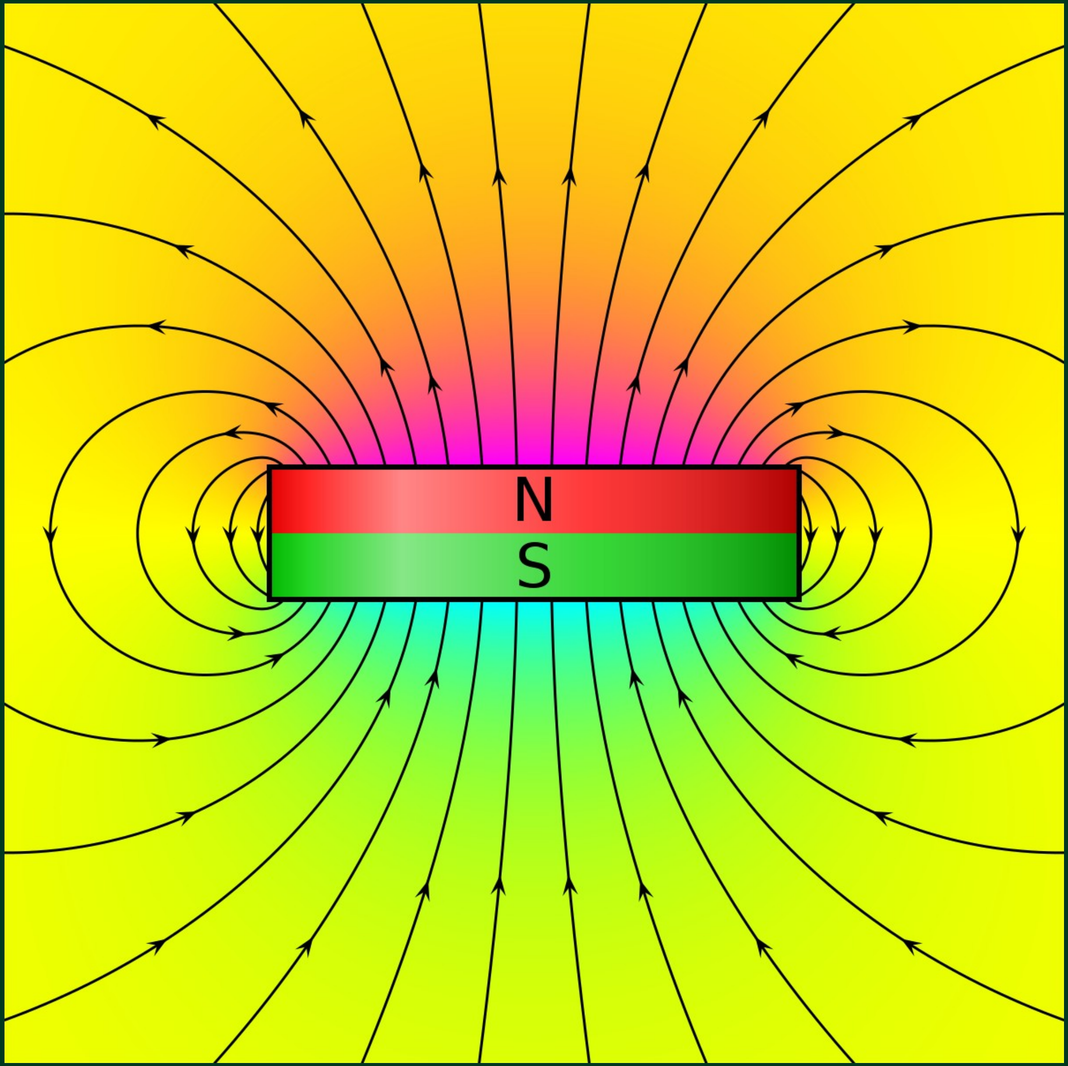
$$F_0 = \frac{\pi}{4}\mu_0 M^2 R^2$$

How large is it?

This goes down as:

$$F(z) \approx \frac{3\mu_0}{2\pi}\frac{m_1 m_2}{z^4}$$

Real fields, or better real field lines



Real fields, or better real field lines

I am a little confused with H, B, M (are you?)

$$\boldsymbol{B} = \mu_0(\boldsymbol{H} + \boldsymbol{M})$$

But the field is B or H???

The only one to remember:

- M and H are in A/m
- M is the contribution of the material
- H is what you apply

The response of the material to the external field is:

$$\boldsymbol{M} = \chi \boldsymbol{H}$$

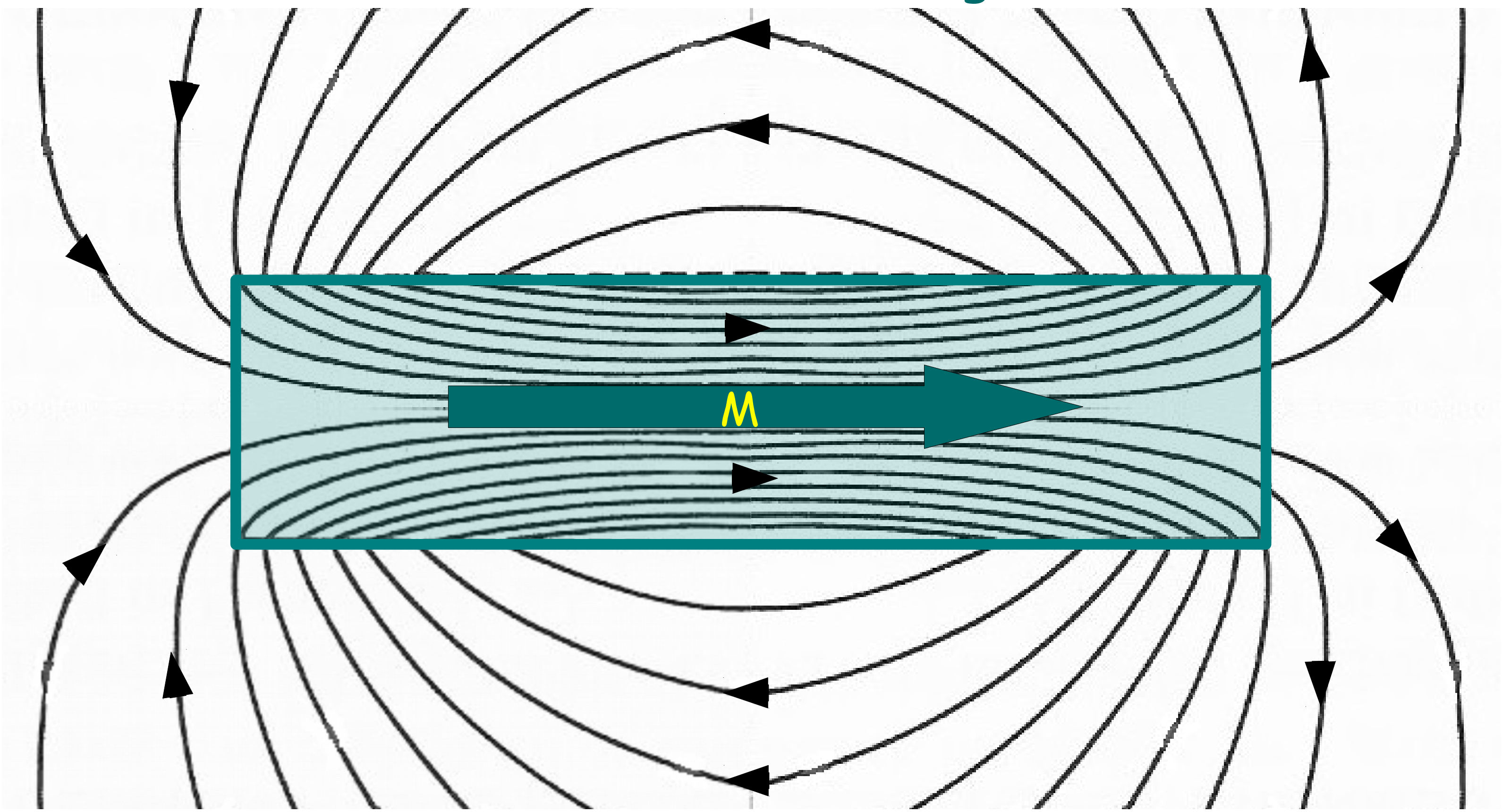
so that...

$$\boldsymbol{B} = \mu_0(\boldsymbol{H} + \chi \boldsymbol{H}) = \mu_0(1 + \chi)\boldsymbol{H} = \mu \boldsymbol{H}$$

But also that... $\boldsymbol{\nabla} \cdot \boldsymbol{B} = 0 \Longrightarrow \boldsymbol{\nabla} \cdot \boldsymbol{M} = -\boldsymbol{\nabla} \cdot \boldsymbol{H}$

Uniform M: no divergence for B, in and out

Magnetization M uniform



Uniform M: divergence for H, in and out

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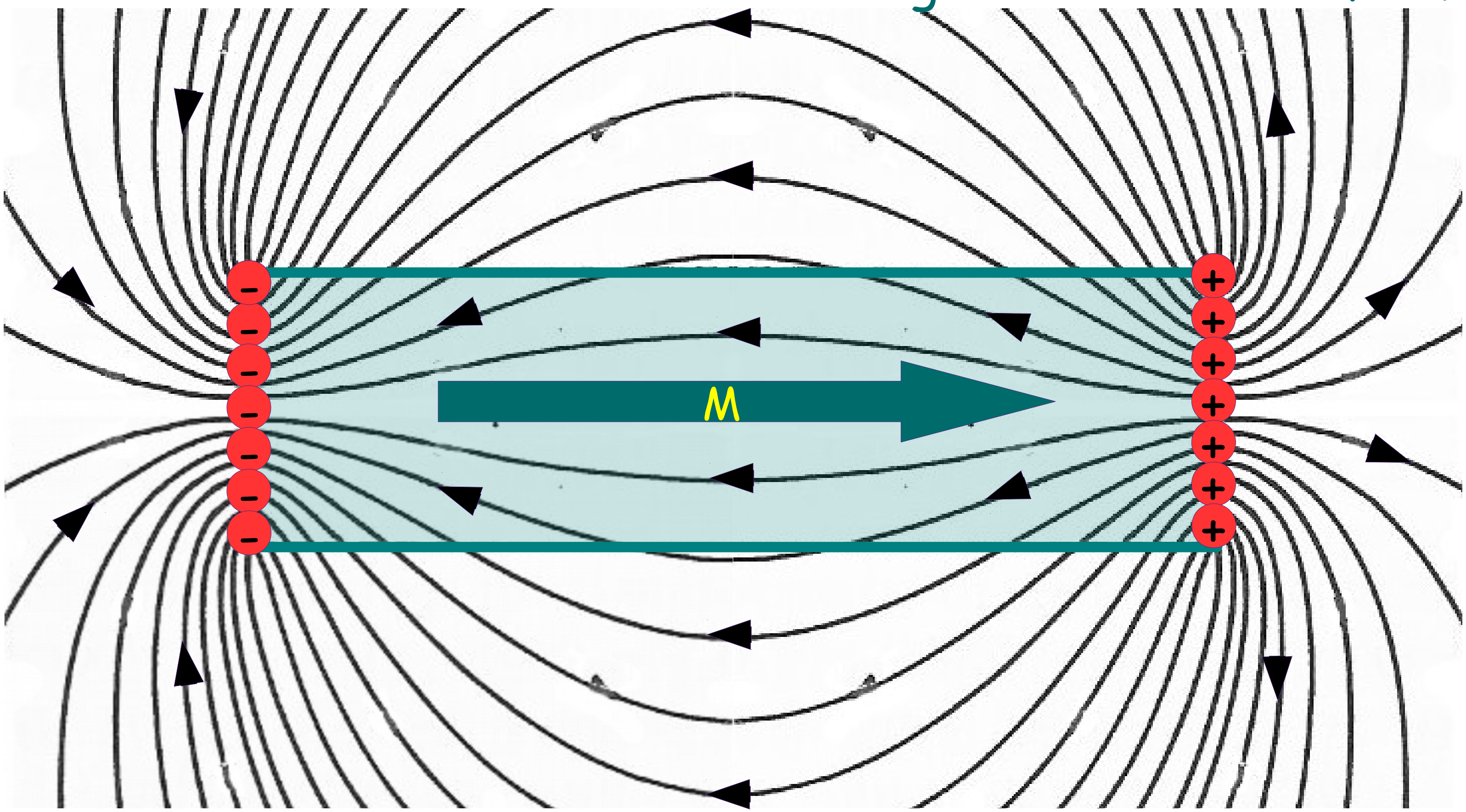
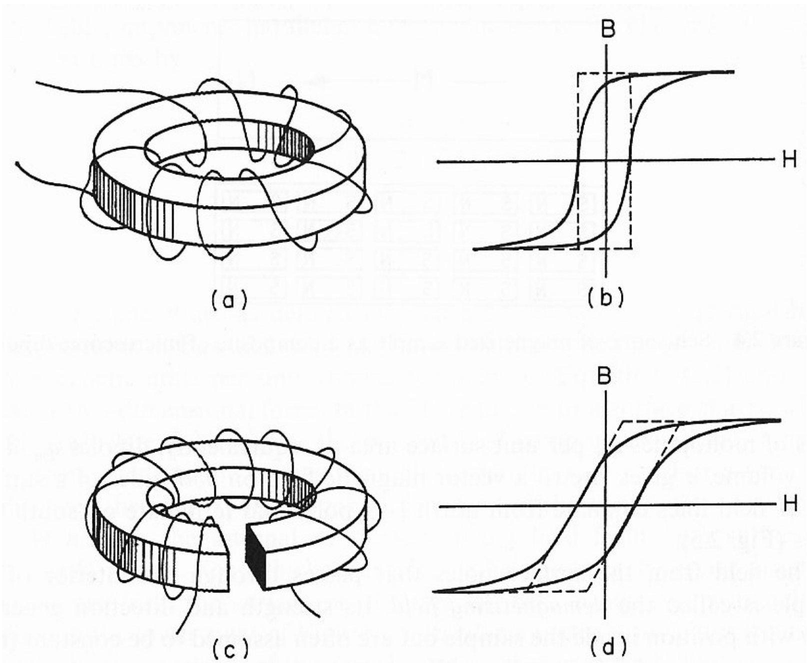


Demagnetizing fields and permeability



$$H_i = H_{app} + H_d = H_{app} - N\,M$$

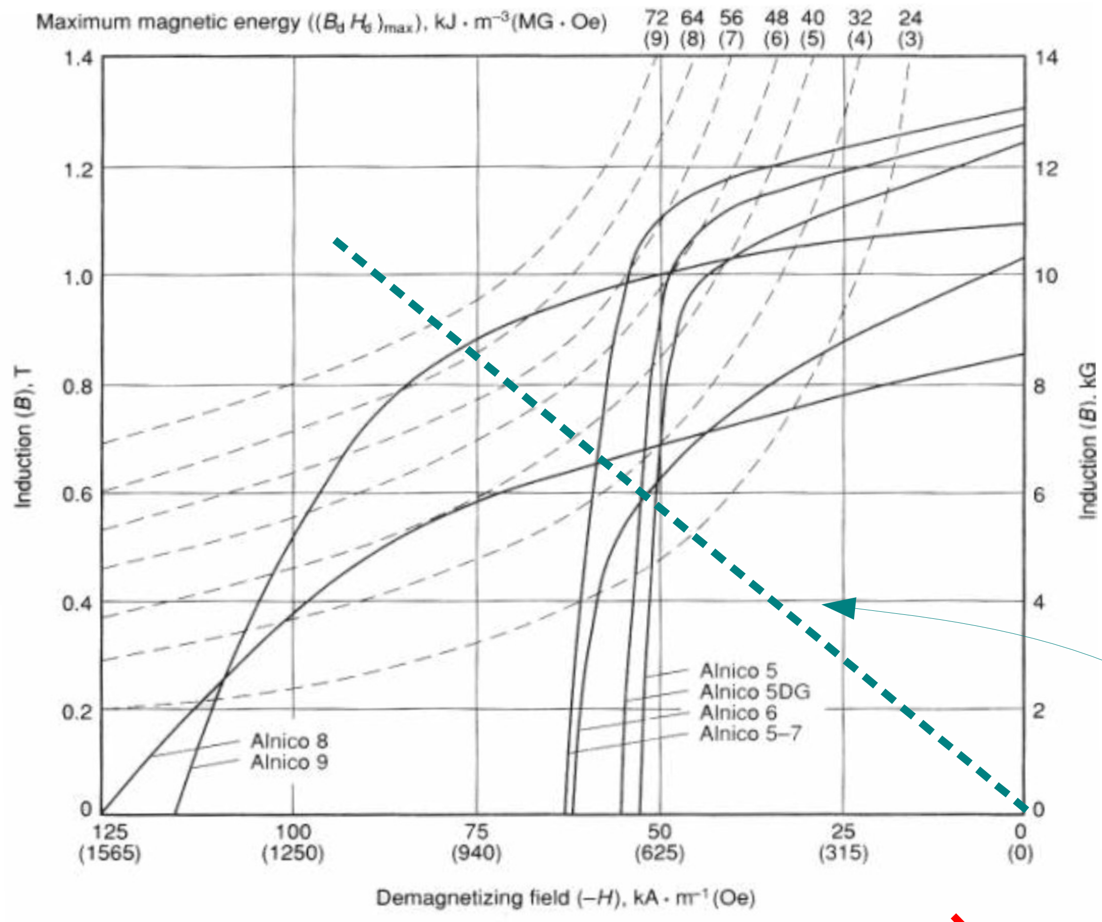
$$M = \chi\left(H_{app} - N\,M\right)$$

$$\chi_{app} = \frac{M}{H_{app}} = \frac{\chi}{1 + N\chi}$$

$$B = \mu_o\left(H_i + M\right)$$

$$B = \mu_o\left(\frac{1}{N} H_{app} - \frac{1-N}{N} H_i\right)$$

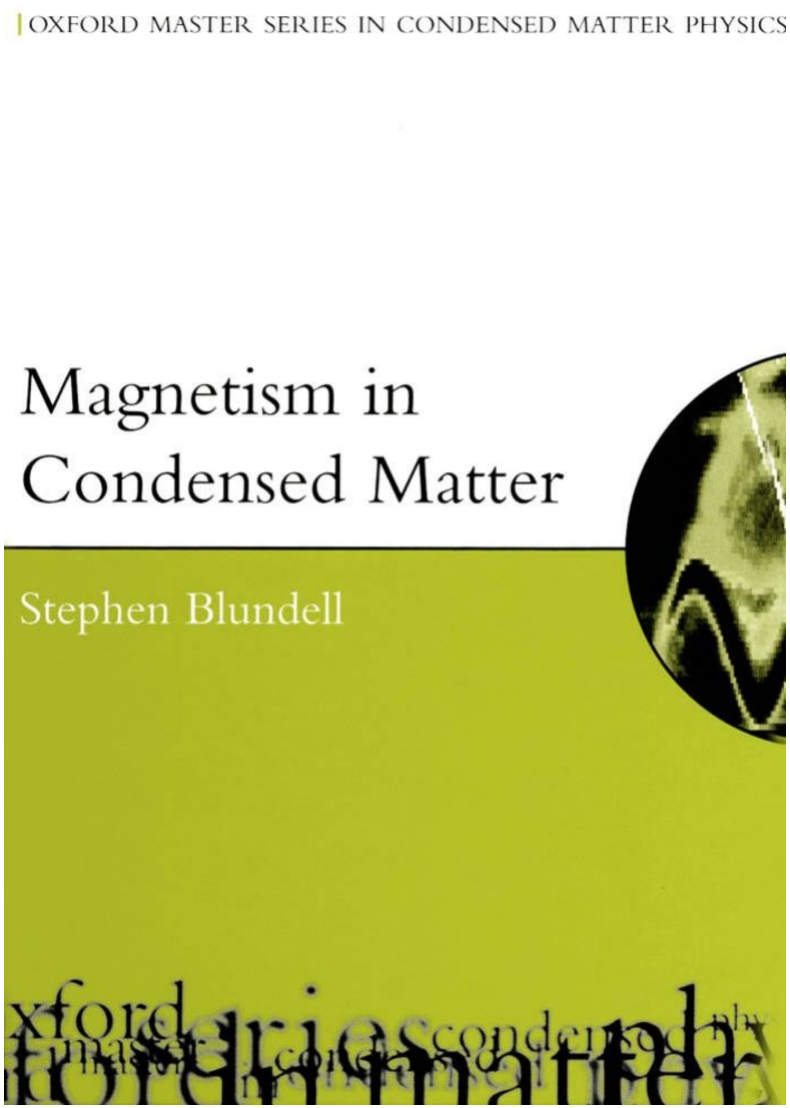
Load curve in permanent magnets



$$B_i = \mu_o \left(\frac{1}{N} H_{app} - \frac{1-N}{N} H_i \right)$$

Two cylinders: one is soft, the other is hard

My guess (agreed by many)



Albert Einstein (1879–1955)

Wander Johannes de Haas (1878–1960)

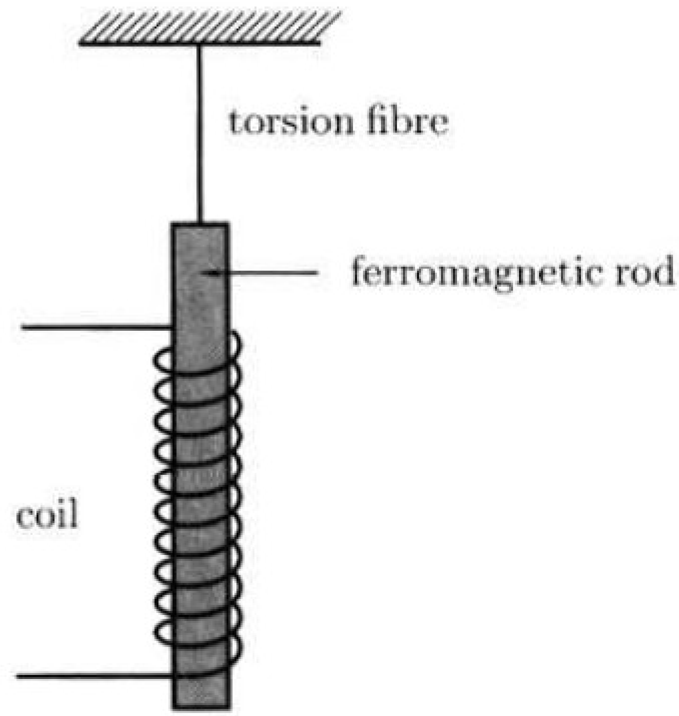
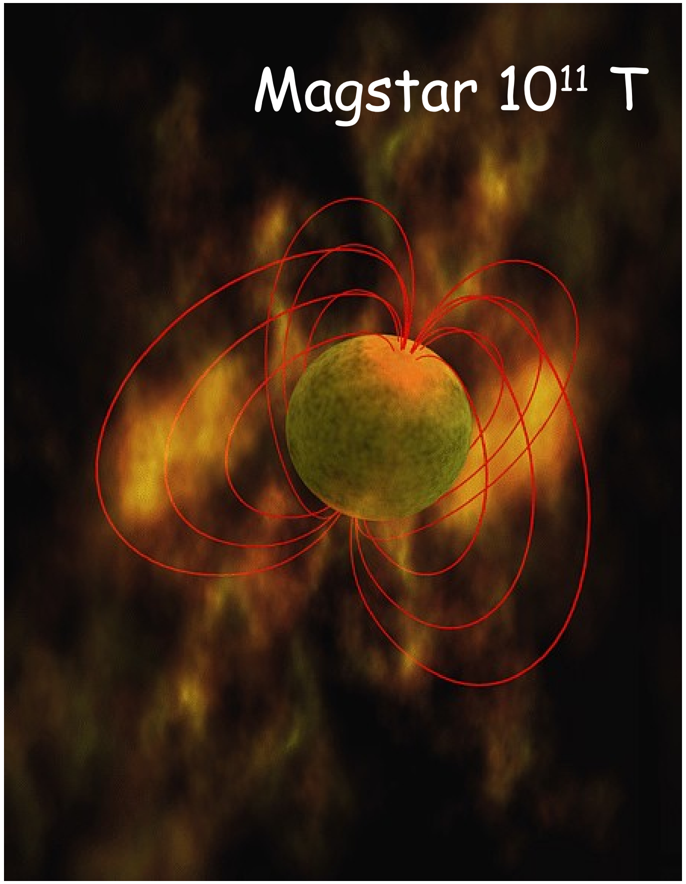


Fig. 1.2 The Einstein–de Haas effect. A ferromagnetic rod is suspended from a thin fibre. A coil is used to provide a magnetic

Some general questions

- Explain me the compass please: ok, the torque = μ x B, but it does make any precession
- How large is the earth magnetic field?
- 1 T is large or small? And 2 T? And 10 T?
- How large is the highest field you can think of?
- Highest Ms? Fe, Co or Ni

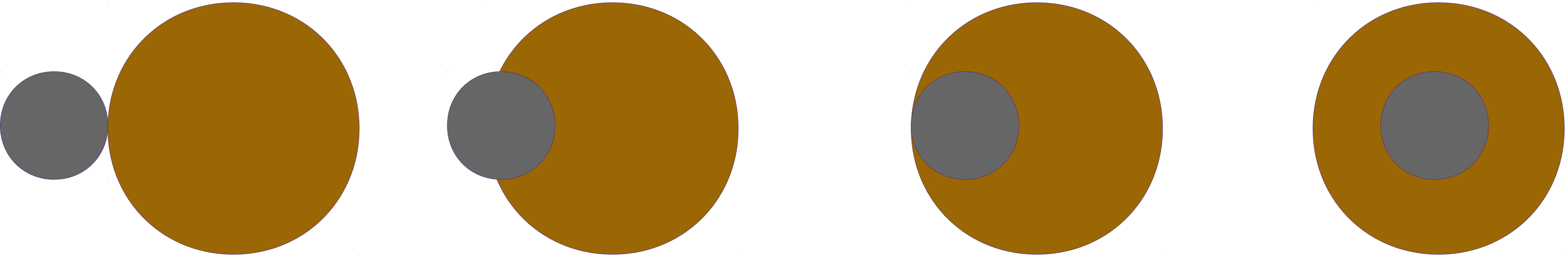
Material	T_c [K]	$\mu_0 M_s$ [T]
Fe	1044	2.16
Co	1398	1.82
Ni	627	0.62
γ-Fe_2O_3		0.52
CrO_2		0.5
$BaFe_{12}O_{19}$	723	0.48
$Nd_2Fe_{14}B$	585	1.61
Sm_2Co_{17}	1100	1.29
$SmCo_5$	993	1.05



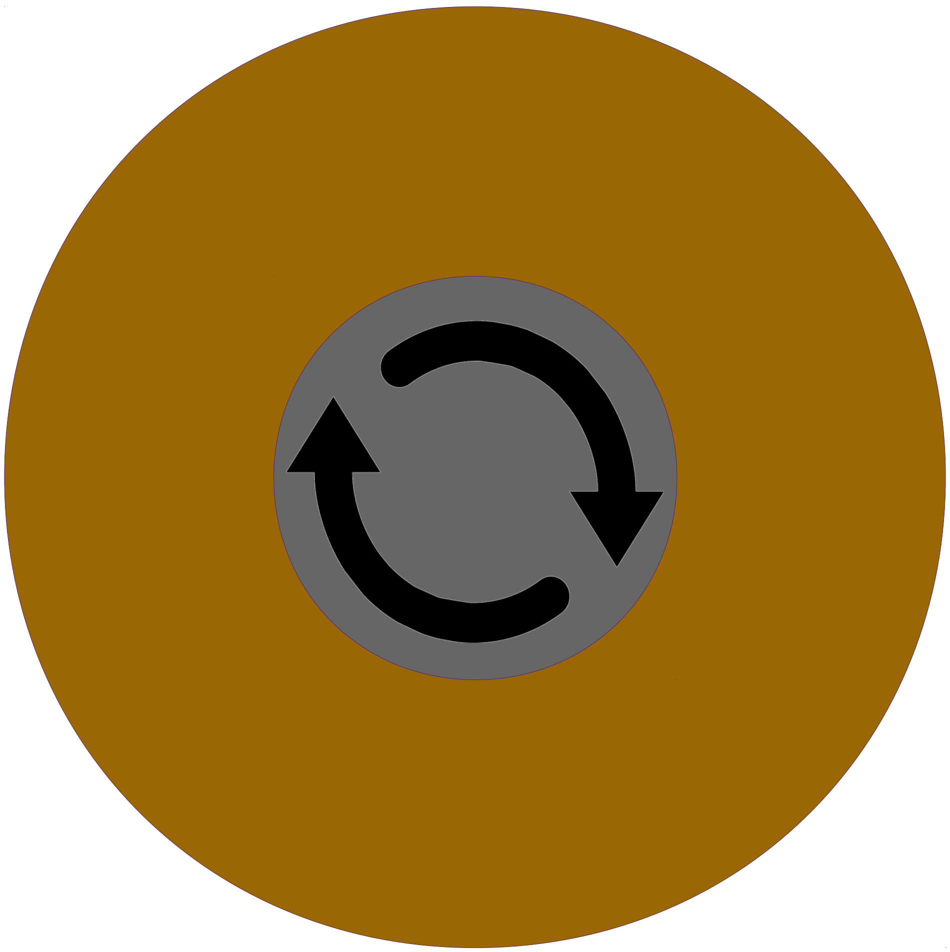
The magnetic pendulum

Eddy currents, what else?

$$e.m.f. = -\frac{d\Phi}{dt}$$



Why the magnet rotates at the end?



The tracks

Questions

Corkscrew

- Do you agree with my interpretation?

Pendulum

- What is the distance to which the pendulum does not stop anymore?
- How the kinetic energy is dissipated?

Tracks

- Can you estimate the force on the disk due to eddy currents compared to the gravitational force? (x = 40 cm, t_eddy = 3 s)

Thank you!

Credits for the videos (from INRIM):
Michaela Kuepferling
Elena Olivetti
Luca Martino