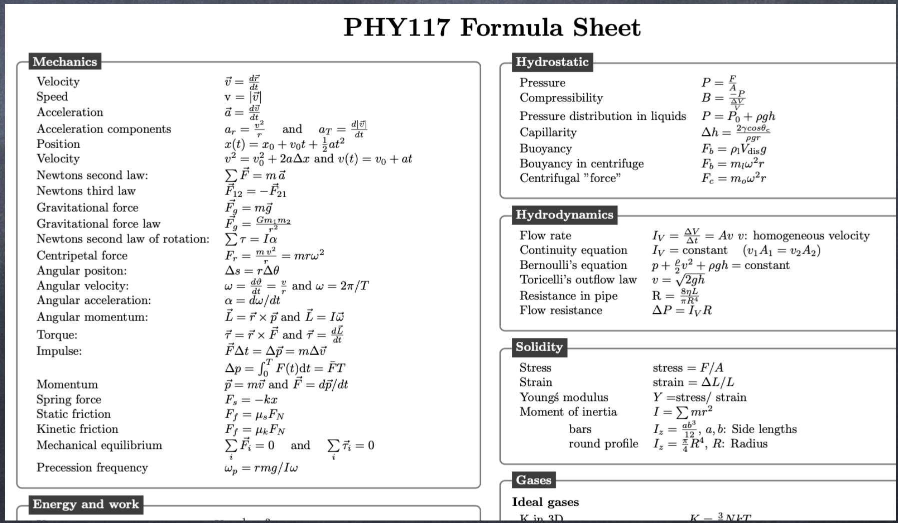
PHY117 HS2023

Week 10, Lecture 1
Nov. 21st, 2023
Prof. Ben Kilminster

preliminary formula sheet for exam in exercises folder



PHY117 Formula Sheet

Mechanics

Velocity	$\vec{v} = \frac{d\vec{r}}{dt}$
Speed	$\mathrm{v} = \|\vec{v}\|$
Acceleration	$\vec{a} = \frac{d\vec{v}}{dt}$
Acceleration components	$a_r = \frac{v^2}{r}$ and $a_T = \frac{d\|\vec{v}\|}{dt}$
Position	$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$
Velocity	$v^2 = v_0^2 + 2a\Delta x$ and $v(t) = v_0 + at$
Newtons second law:	$\sum \vec{F} = m\,\vec{a}$
Newtons third law	$\vec{F}_{12} = -\vec{F}_{21}$
Gravitational force	$\vec{F}_g = m\vec{g}$
Gravitational force law	$\vec{F}_g = \frac{Gm_1m_2}{r^2}$
Newtons second law of rotation:	$\sum \tau = I\alpha$
Centripetal force	$F_r = \frac{m\,v^2}{r} = mr\omega^2$
Angular positon:	$\Delta s = r\Delta\theta$
Angular velocity:	$\omega = \frac{d\vartheta}{dt} = \frac{v}{r}$ and $\omega = 2\pi/T$
Angular acceleration:	$\alpha = d\omega/dt$
Angular momentum:	$\vec{L} = \vec{r} \times \vec{p}$ and $\vec{L} = I\vec{\omega}$
Torque:	$\vec{\tau} = \vec{r} \times \vec{F}$ and $\vec{\tau} = \frac{d\vec{L}}{dt}$
Impulse:	$\vec{F}\Delta t = \Delta\vec{p} = m\Delta\vec{v}$
	$\Delta p = \int_0^T F(t)\mathrm{d}t = \bar{F}T$
Momentum	$\vec{p} = m\vec{v}$ and $\vec{F} = d\vec{p}/dt$
Spring force	$F_s = -kx$
Static friction	$F_f = \mu_s F_N$
Kinetic friction	$F_f = \mu_k F_N$
Mechanical equilibrium	$\sum_i \vec{F}_i = 0$ and $\sum_i \vec{\tau}_i = 0$
Precession frequency	$\omega_p = rmg/I\omega$

Energy and work

Hydrostatic

Pressure	$P = \frac{F}{A}$
Compressibility	$B = \frac{-P}{\frac{\Delta V}{V}}$
Pressure distribution in liquids	$P = P_0 + \rho gh$
Capillarity	$\Delta h = \frac{2\gamma cos\theta_c}{\rho gr}$
Buoyancy	$F_b = \rho_{\mathrm{l}} V_{\mathrm{dis}} g$
Bouyancy in centrifuge	$F_b = m_l\omega^2 r$
Centrifugal "force"	$F_c = m_o\omega^2 r$

Hydrodynamics

Flow rate	$I_V = \frac{\Delta V}{\Delta t} = Av$ v: homogeneous velocity
Continuity equation	$I_V =$ constant $(v_1A_1 = v_2A_2)$
Bernoulli's equation	$p + \frac{\rho}{2}v^2 + \rho gh =$ constant
Toricelli's outflow law	$v = \sqrt{2gh}$
Resistance in pipe	$\mathrm{R} = \frac{8\eta L}{\pi R^4}$
Flow resistance	$\Delta P = I_V R$

Solidity

Stress	stress $= F/A$
Strain	strain $= \Delta L/L$
Youngś modulus	$Y =$stress/ strain
Moment of inertia	$I = \sum mr^2$
bars	$I_z = \frac{ab^3}{12}$, a, b: Side lengths
round profile	$I_z = \frac{\pi}{4}R^4$, R: Radius

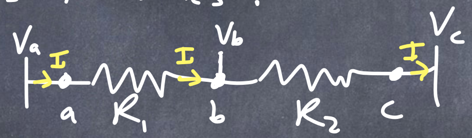
Gases

Ideal gases

LAST WEEK:

Resistors in series:

Note: opposite rules as for capacitors



Equivalent resistance

$$R_{eq} = R_1 + R_2 + \dots$$

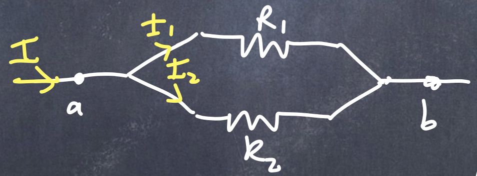
$$V_b = V_a - I R_1$$

$$V_c = V_a - I R_1 - I R_2$$

$$I_a = I_b = I_c = I$$

Potential decreases, current stays same.

Resistors in parallel:



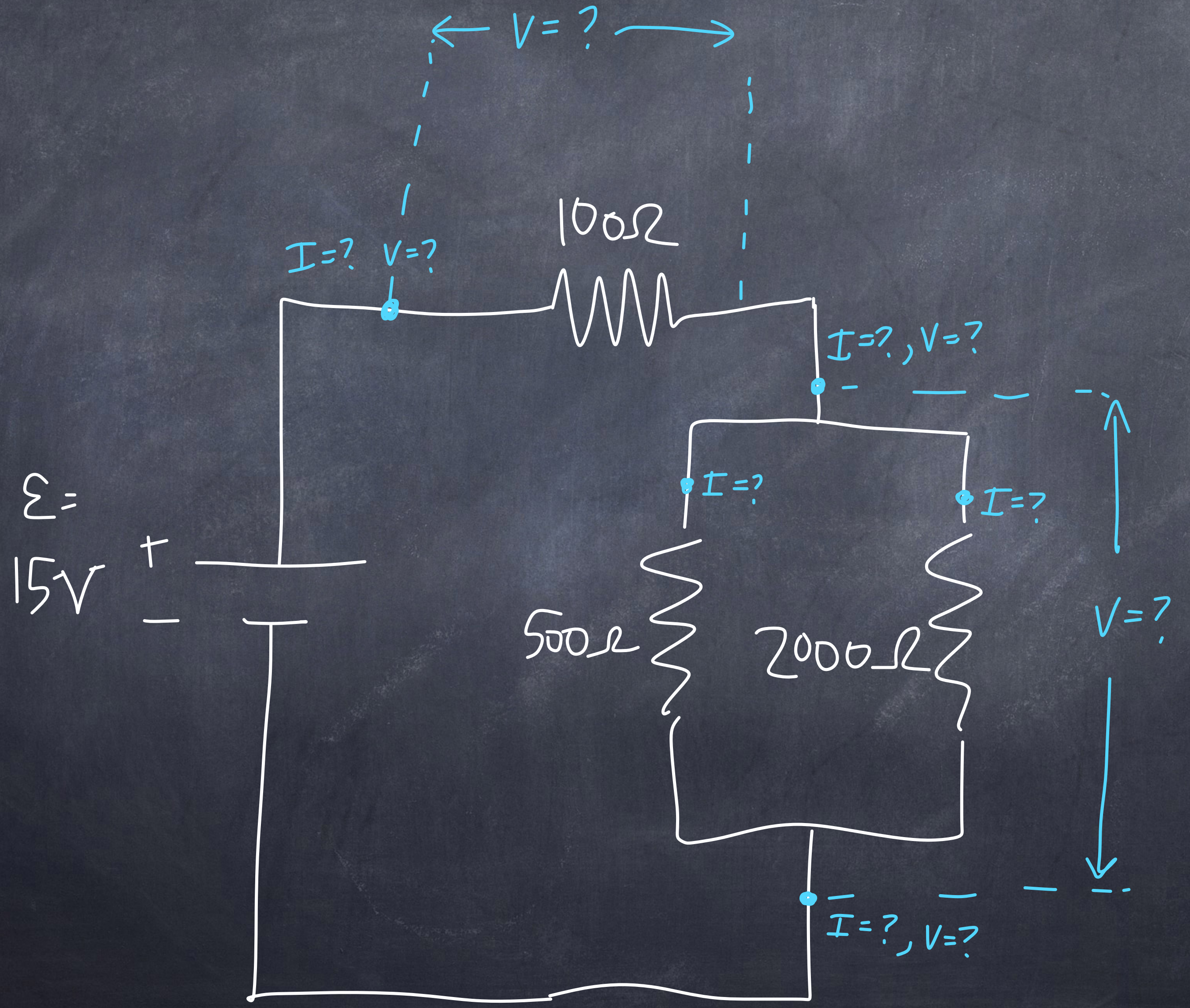
Equivalent resistance decreases.
(More ways for current to flow)

$$I = I_1 + I_2$$

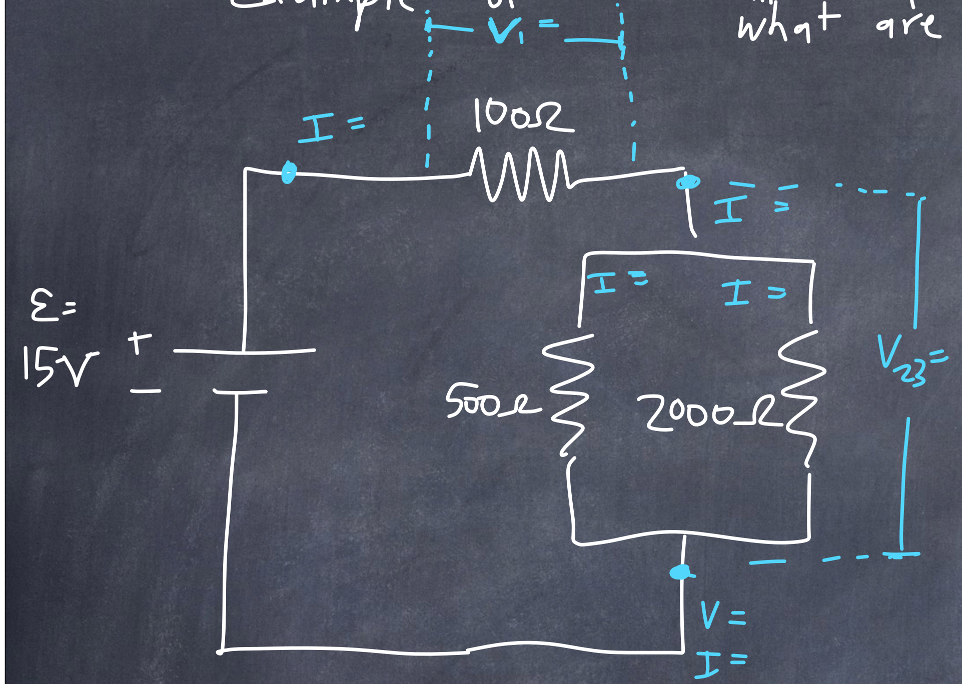
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

voltage drop $V_a - V_b$ is same across both paths: $V_{ab} = I_1 R_1 = I_2 R_2$

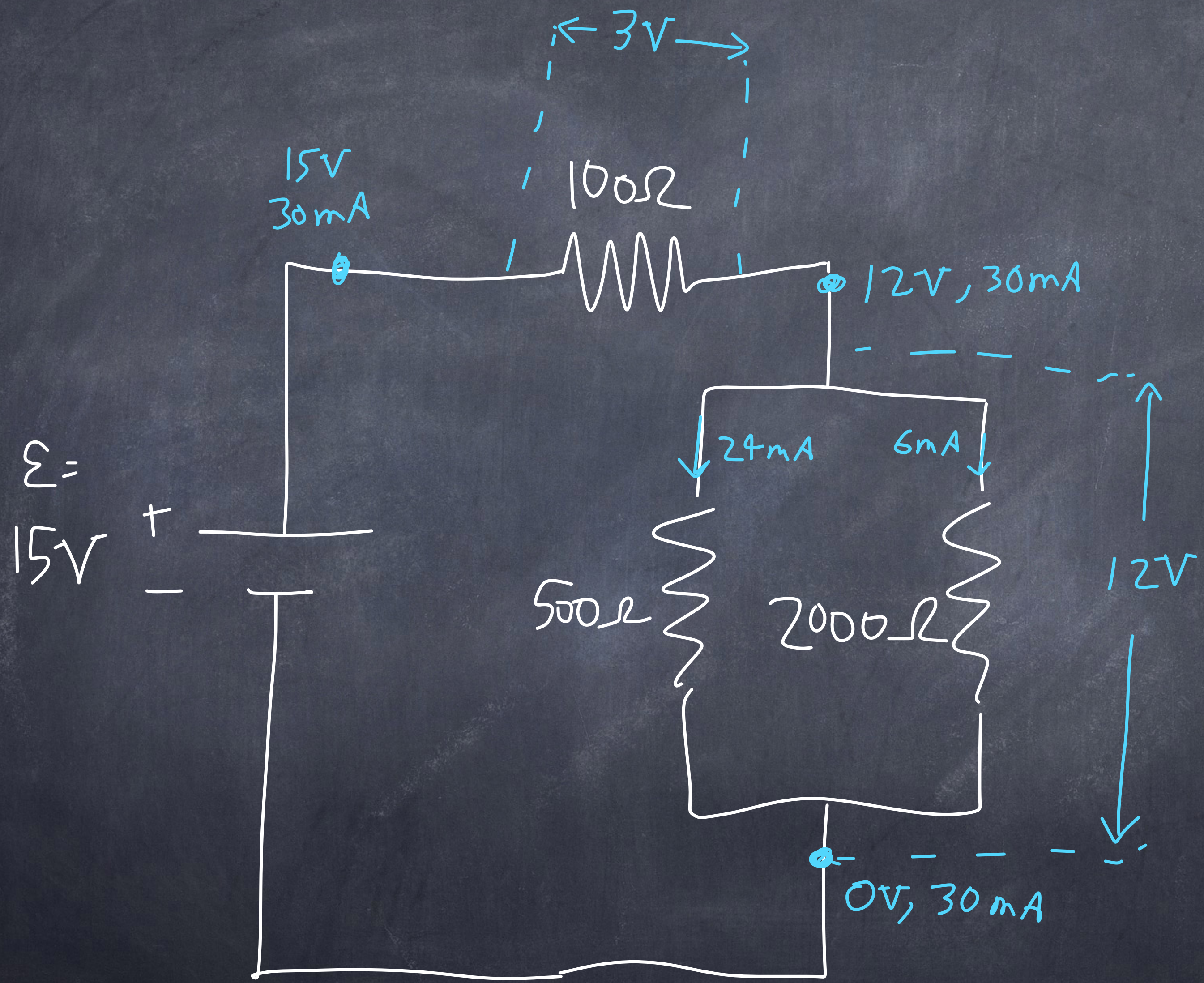
what are the requested voltages + currents ?

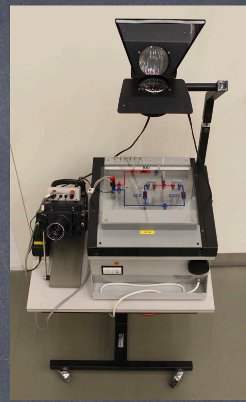


Example of circuit with resistors in parallel + series:
what are values of labeled currents + voltages?



Solution:





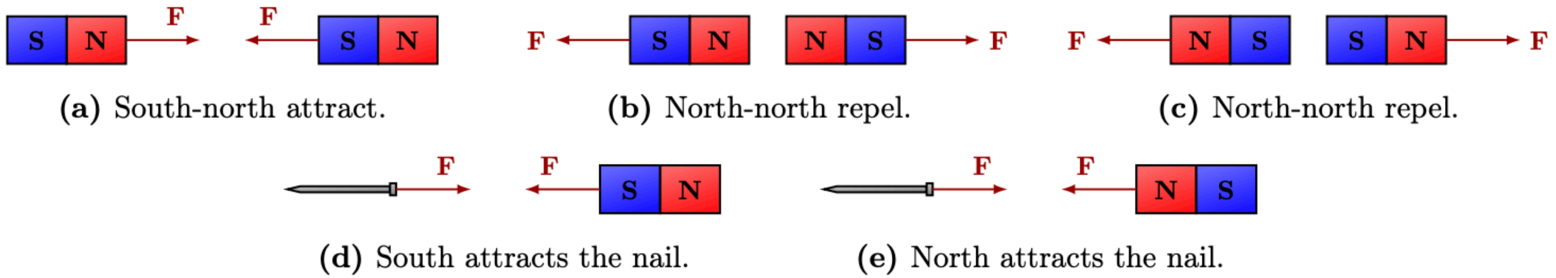
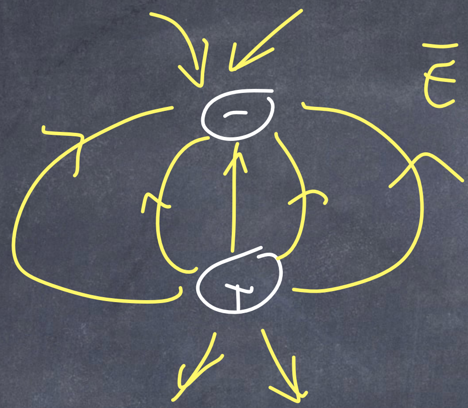


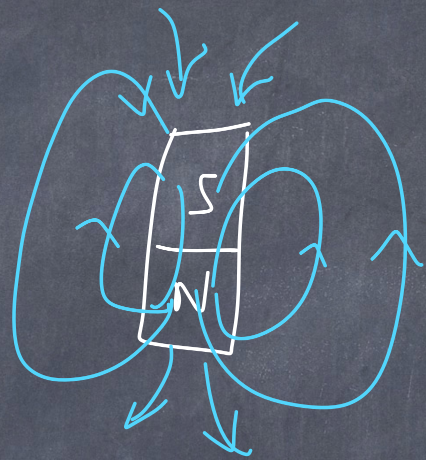
Figure 7.1: The magnetic force between two bar magnet depends on their orientation, but between a non-magnetic nail and bar magnet, orientation does not matter.

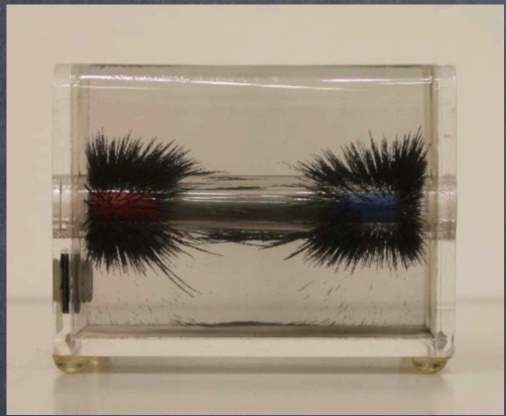
(a) The magnetic field of bar magnet looks like the electric field of an electric dipole. The field lines close their loops inside the bar magnet.

(b) Earth's magnetic field looks like that of a bar magnet. Magnetic compasses point to Earth's geographic north pole, the magnetic south pole.

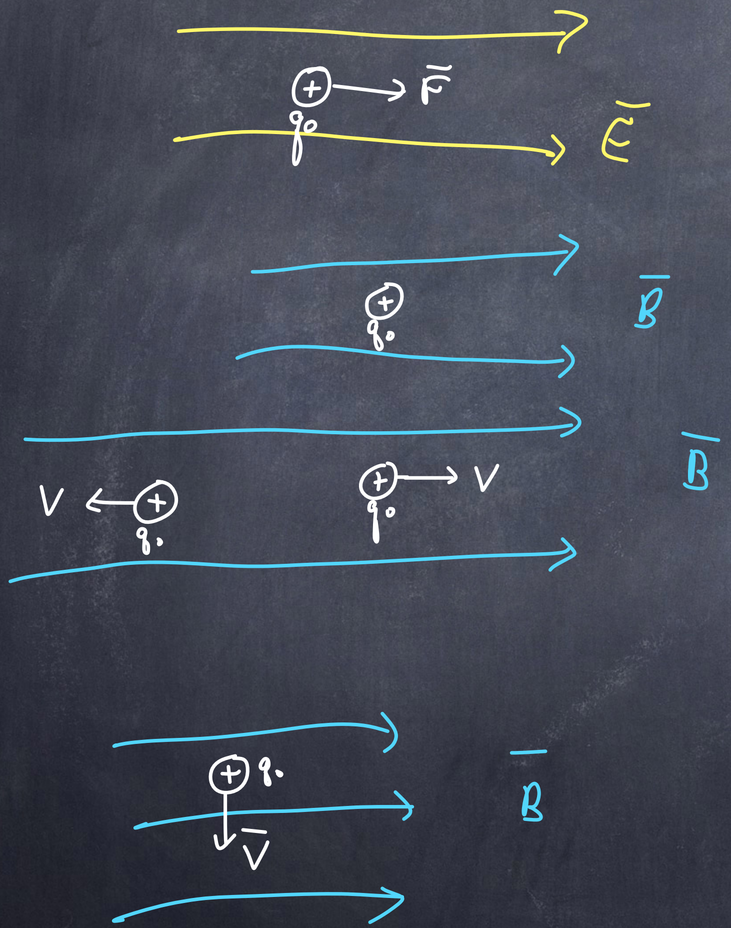
Figure 7.2: Bar magnets and the Earth create a magnetic dipole field (purple).


$\bar{E}$
−
+


S
N




VisaLux
Favorit 400



F
q_0
E
q_0
B
V
q_0
q_0
V
B
q_0
V
B

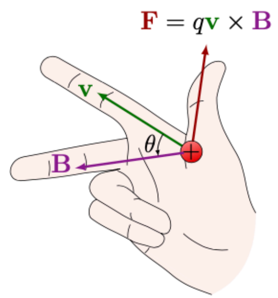
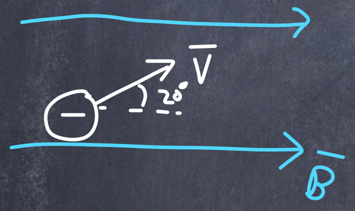
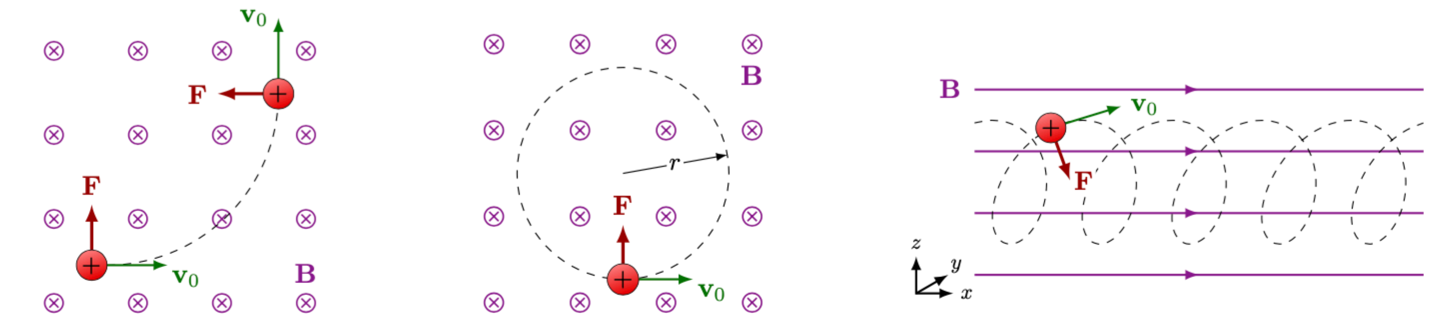


Figure 7.4: Right-hand rule for the magnetic force on a positive charge $q > 0$.



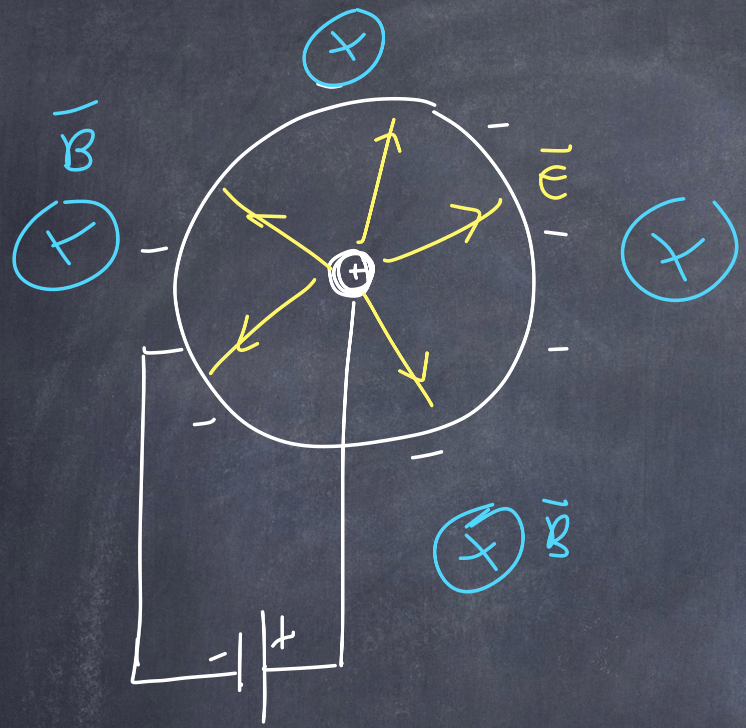


(a) Charge is bent in a magnetic field **B**.

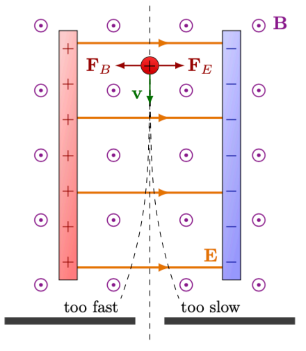
(b) Charge with a constant velocity, perpendicular to **B** makes circles.

(c) Charge with constant velocity, not perpendicular to **B**, makes makes spirals.

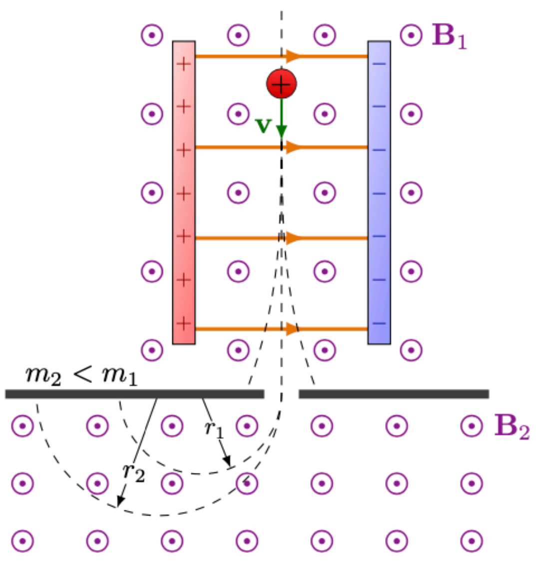
Figure 7.5: Charge with a non-zero velocity, not parallel to a uniform magnetic field **B**, experiences a force perpendicular to the velocity and magnetic field.



B
E
B

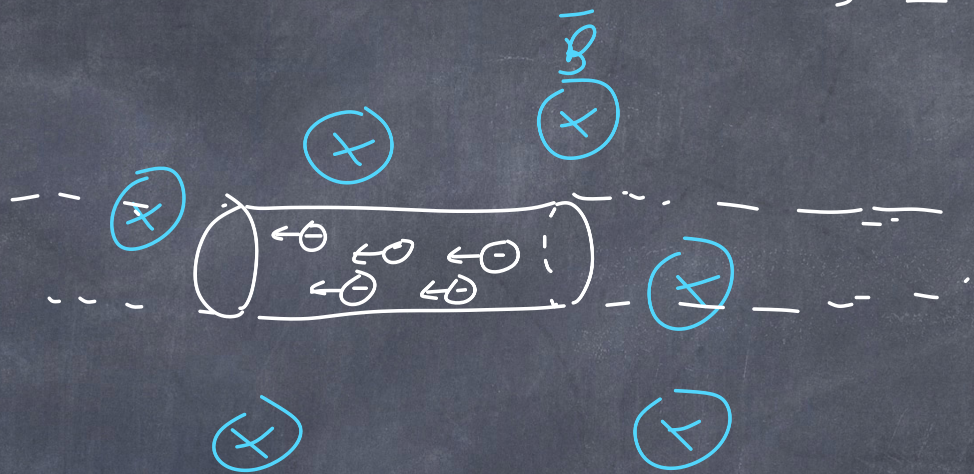


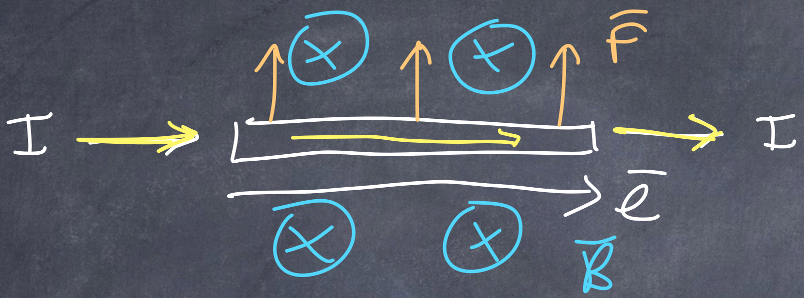
(a) Velocity selector.

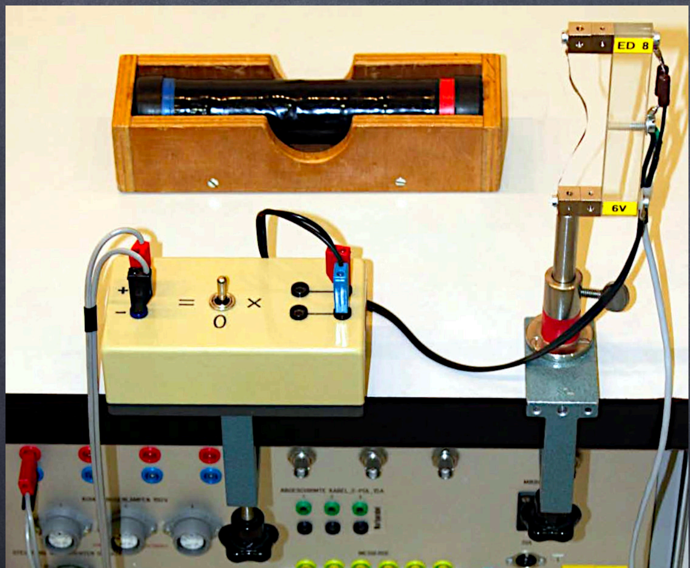


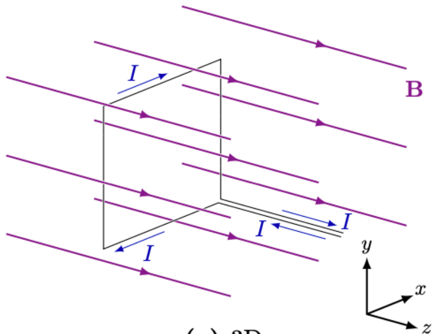
(b) Mass spectrometer.

what if we have current of electric charges
I moving $\perp$ $\bar{B}$-field
?

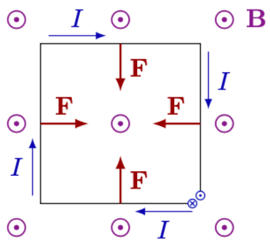



I
F
I
e
B


ED 8
6V



(a) 3D.



(b) 2D in xy plane.

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

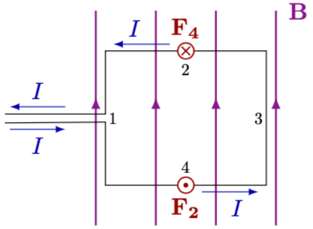
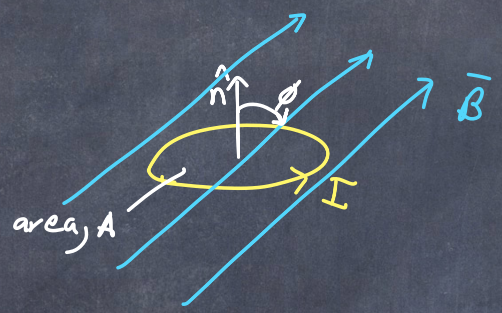


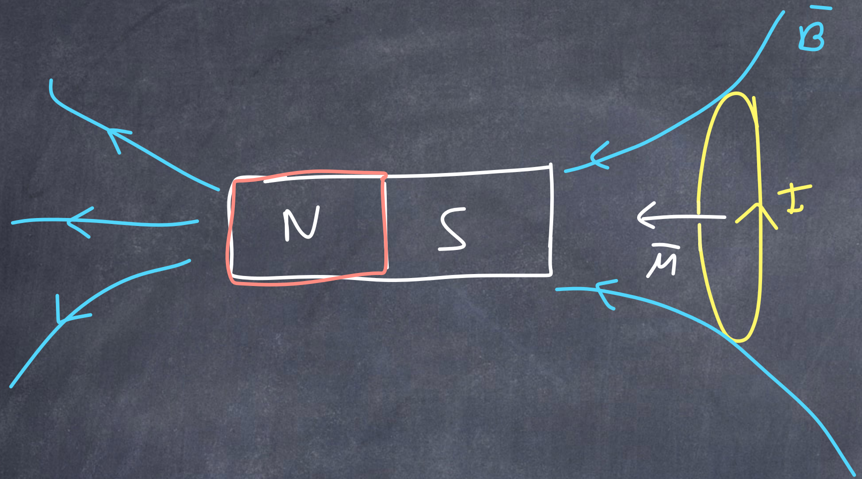
Figure 7.10: Rectangular current loop in an external magnetic field **B**.


$\hat{n}$
ϕ
$\bar{B}$
I
area, A

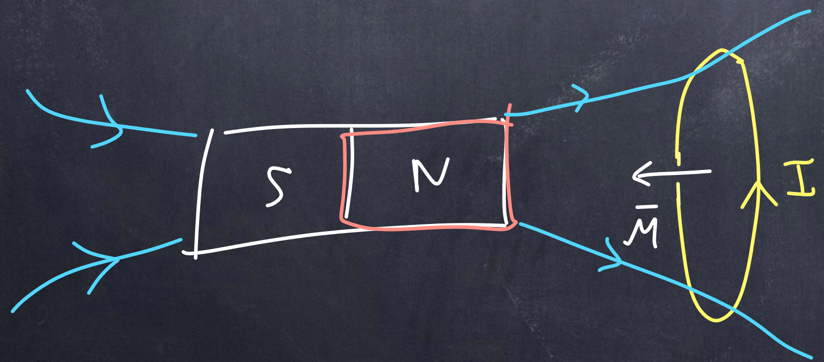
(a) Magnetic moment of a current loop in a uniform magnetic field.

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

Figure 7.11: Magnetic moment.



B
N
S
I
M



S
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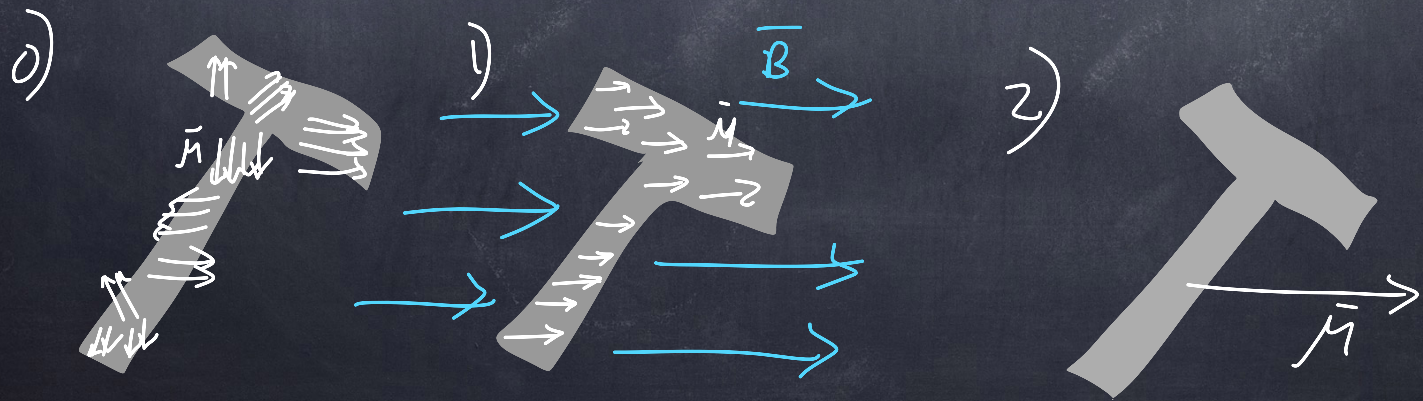
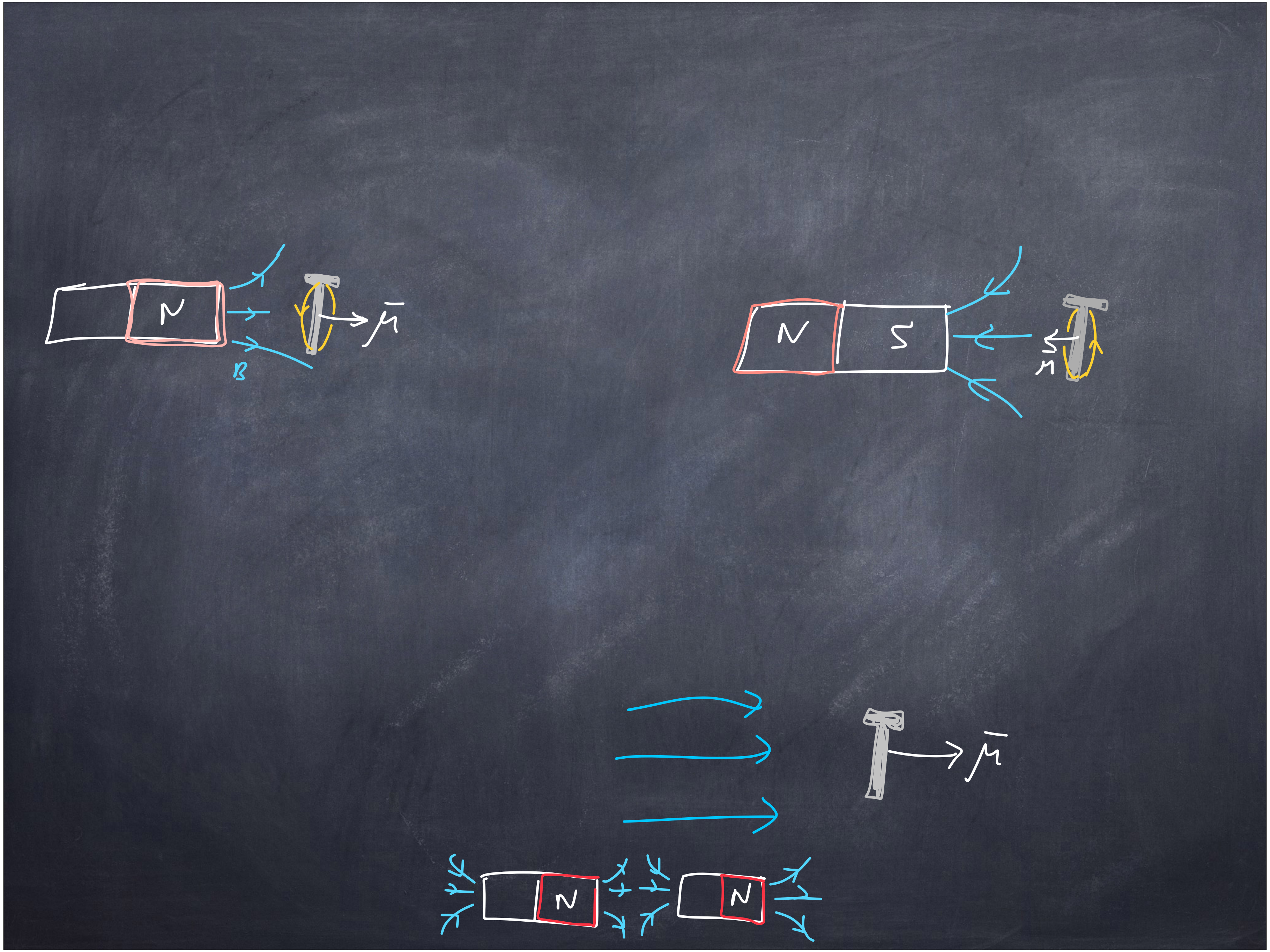
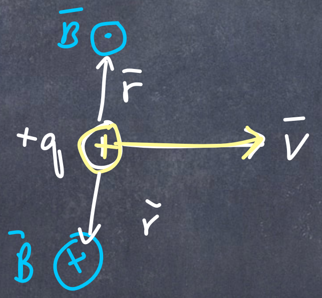
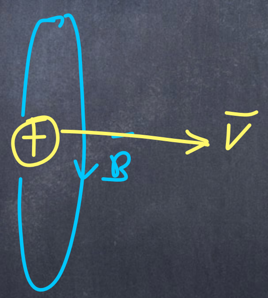
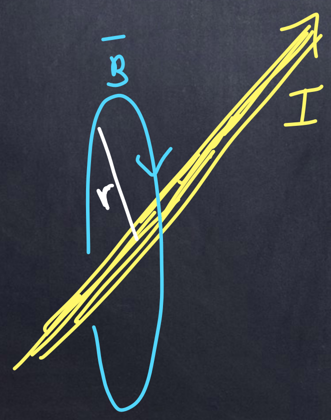


0)
$\bar{M}$
1)
$\bar{B}$
$\bar{M}$
2)
$\bar{M}$


N
B
$\bar{\mu}$
N
S
μ
$\bar{\mu}$
N
N


B
r
+q
v
r
B


v
B


B
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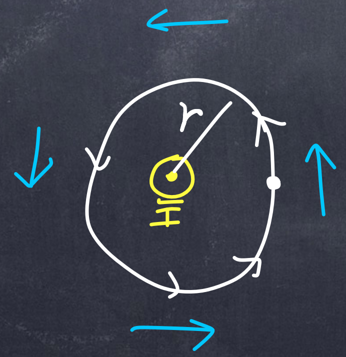
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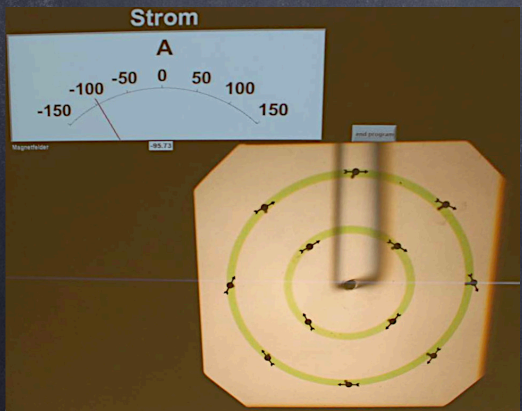
Strom
A
-150
-100
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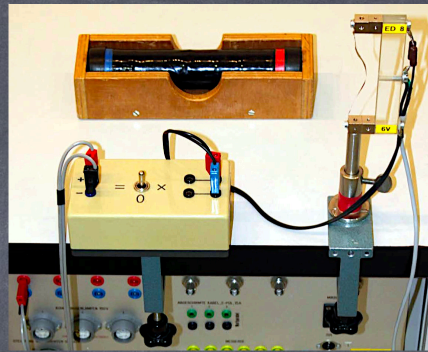
ED2

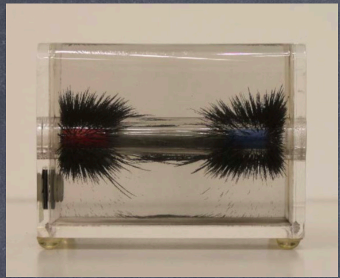
ED1

ED5

ED7



ED8



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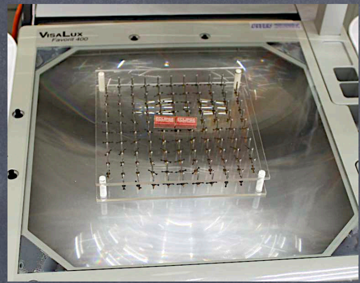

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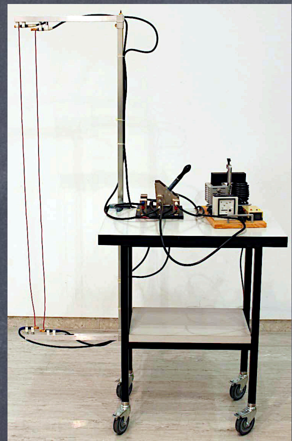

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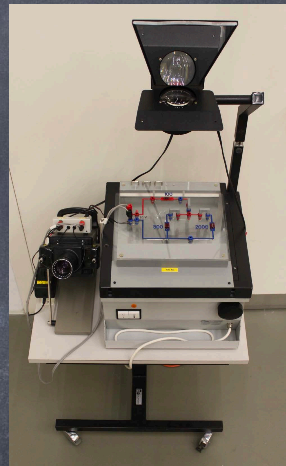

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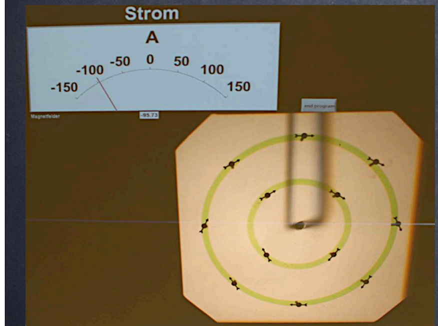

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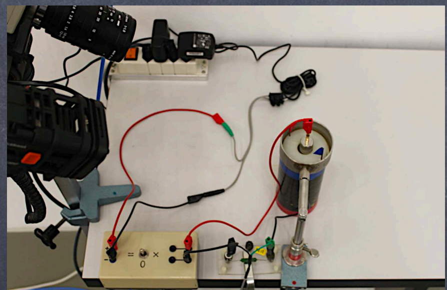

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