Exam Preparation: Electrostatics, Magnets, Electric Circuits

Theory: Answer the questions and explain the concepts by heart

a) Vector/scalar
b) Give two examples of scalars
c) Give two examples of vectors
d) Properties of magnets
e) What do magnetic materials contain on a microscopic level?
f) When is a material magnetised?
g) What is the difference between a soft magnetic material and a hard magnetic material?
h) How can the magnetic domains be brought out of alignment (two options)?
i) Magnetic field
j) Definition of the direction of a magnetic field line
k) Elementary charge
l) Electric Field
m) Electric field strength
n) Definition of the direction of an electric field line
o) Uniform field
p) Voltage
q) Electric current
r) What is the purpose of electric current?
s) What requirements need to be met for an electric current to flow?
t) Series circuit
u) Parallel circuit
v) Direct current
w) Alternating current

Physical quantities: Know these physical quantities by heart (symbol and unit)

	symbol	unit		symbol	unit
time			displacement		
velocity			acceleration		
force			mass		
work			power		
charge			electric current		
heat			acceleration of free fall		
electric field strength			voltage		
energy			internal energy		

Formulae: A formula sheet will be handed out. Please find the formula sheet on massenpunkt.ch.

Skills:

- Transform equations, insert numbers with units into the equation, calculate results correctly
- Round your results to the correct number of significant digits and write your answer with a power of ten in the normalized scientific format
- Draw and read scientific graphs
- draw and read electric field line patterns
- draw and read magnetic field line patterns
- Convert the unit *Pascal* to *bar* and vice versa
- Convert the unit *eV* to *J* and vice versa
- Convert units of area and volume
- draw and read electric circuit diagrams

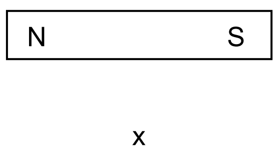
Exercises:

An algebraic solution and all values used in calculations are required to get the full mark.

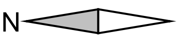
All work sheets plus assignment sheets A47 – A50

Additional problems

1.

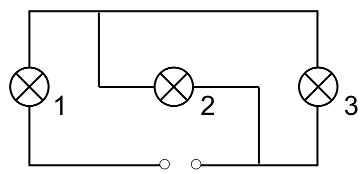


a) Draw the field line pattern of this bar magnet.
b) A little compass is placed in the field at the point x. Draw in the picture in what way it aligns in the magnetic field of the bar magnet.

compass: N  S

2. The voltage between the plates of a plate capacitor is 0.08997040 kV while the plates are 0.600 cm spaced apart. The electric field is to be calculated.
a) Place a dot above the significant figures of the values which are required in the calculation. How many significant digits do they have? How many significant figures does your final answer require?
b) Calculate the magnitude of the electric field.
c) Round your result to the correct number of significant figures and write it in the normalized scientific notation (with a power of ten).

3. Which ones of the lamps are lit, if you unscrew
a) lamp 1
b) lamp 2 from the socket?
c) Which lamps are connected in parallel, which ones are connected in series?

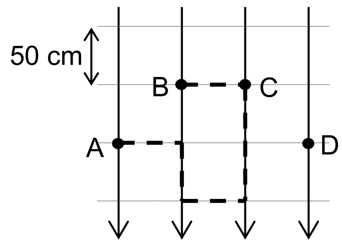


4. During 0.079300 min, 1.781990 · 10^{17} electrons are passing through a cross section of the filament of a light bulb. The electric current (in A) is to be calculated.
a) Place a dot above the significant figures of the values which are required in the calculation. How many significant digits do they have? How many significant figures does your final answer require?
b) Calculate the electric current (in A).
c) Round your result (in A) to the correct number of significant figures and write it in the normalized scientific notation (with a power of ten).

5. A charged cotton ball (q = 2.4 · 10^{-9} C, m = 5.6 g) is accelerated in a vacuum by a voltage of U = 15.0 kV.
a) How much kinetic energy does it gain in the process? (in J and in eV)
b) What is the velocity of the cotton ball at the end of the acceleration process, if initially it was at rest?

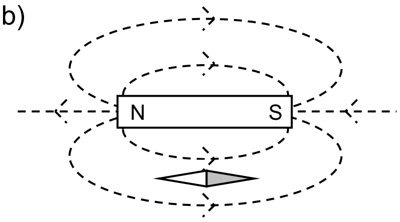
6. An oil drop (ρ = 0.973 $\frac{\text{g}}{\text{cm}^3}$, r = 1.20 · 10^{-3} mm) carries three elementary charges and is located in the vertical uniform electric field of a Millikan capacitor with its plates d = 0.500 cm spaced apart.
How much voltage is needed in order for the oil drop to hover at equilibrium?

7. The electric field lines of the electric field of the earth (E = 130 $\frac{\text{V}}{\text{m}}$) are pointing downwards. (see picture).
a) What is the voltage between the points A and B?
b) How much work needs to be performed, if a small charged sphere (Q_1 = - 1.9 ·10^{-6} C, m = 0.045 g) is transported along the broken line from A to B?
c) If a negatively charged sphere (Q_2 = 5.3 · 10^{-5} C) is released at point D it is accelerated downwards with an acceleration of 4.97 $\frac{\text{m}}{\text{s}^2}$. What's its mass?



Solutions:

1. a) and b)



2. a) $U = 0.0\dot{8}\dot{9}\dot{9}\dot{7}\dot{0}\dot{4}\dot{0}$ kV: 7, $d = 0.\dot{6}\dot{0}\dot{0}$ cm: 3; result: 3

   b) $E = \frac{U}{d} = \frac{89.97040 \text{ V}}{6.00 \cdot 10^{-3} \text{ m}} = 14'995.067 \frac{\text{V}}{\text{m}} = \underline{\underline{15'000 \frac{\text{V}}{\text{m}}}} = \underline{\underline{15.0 \frac{\text{kV}}{\text{m}}}}$

   c) $\underline{\underline{1.50 \cdot 10^{4} \frac{\text{V}}{\text{m}}}}$

3. a) none
   b) 1 and 3
   c) 2 and 3 in parallel, in series to 1

4. a) $t = 0.0\dot{7}\dot{9}\dot{3}\dot{0}\dot{0}$ min: 5 significant digits, $n = \dot{1}.\dot{7}\dot{8}\dot{1}\dot{9}\dot{9}\dot{0} \cdot 10^{17}$: 7 significant digits
   $e = \dot{1}.\dot{6}\dot{0}\dot{2} \cdot 10^{-19}$ C, 4 significant digits, result: 4 digits

   b) $I = \frac{Q}{t} = \frac{n \cdot e}{t} = \frac{1.781990 \cdot 10^{17} \cdot 1.602 \cdot 10^{-19} \text{ C}}{0.079300 \cdot 60 \text{ s}} = 0.005999891 \text{ A} = 5999891 \cdot 10^{-3} \text{ A}$

   c) $I = \underline{6.000 \cdot 10^{-3} \text{ A}}$

5. a) $W = Q \cdot U = 2.4 \cdot 10^{-9} \text{ C} \cdot 15'000 \text{ V} = \underline{\underline{3.6 \cdot 10^{-5} \text{ J}}} = \underline{\underline{2.25 \cdot 10^{14} \text{ eV}}}$

   b) $v = \sqrt{\frac{2 \cdot W}{m}} = \sqrt{\frac{2 \cdot 3.6 \cdot 10^{-5} \text{ J}}{0.0056 \text{ kg}}} = \underline{\underline{0.11 \frac{\text{m}}{\text{s}}}}$

6. Equilibrium of forces: $F_G = F_{el}$ $\quad m \cdot g = q \cdot E = q \cdot \frac{U}{d}$ $\quad q = 3 \cdot e$

   $m = \rho \cdot V = \rho \cdot \frac{4\pi}{3} \cdot r^3 = 7.04 \cdot 10^{-12} \text{ g} = 7.04 \cdot 10^{-15} \text{ kg}$

   $$U = \frac{m \cdot g \cdot d}{3e} = \frac{\rho \cdot \frac{4\pi}{3} \cdot r^3 \cdot g \cdot d}{3e} = \frac{973 \frac{\text{kg}}{\text{m}^3} \cdot \frac{4\pi}{3} \cdot \left(1.20 \cdot 10^{-6} \text{m}\right)^3 \cdot 9.81 \frac{\text{m}}{\text{s}^2} \cdot 0.00500 \text{ m}}{3 \cdot 1.602 \cdot 10^{-19} \text{ C}} = \underline{\underline{719 \text{ V}}}$$

7. a) $U = E \cdot d = 130 \frac{\text{V}}{\text{m}} \cdot 0.50 \text{ m} = \underline{\underline{65 \text{ V}}}$

   b) weight downwards, electric force upwards:
   $F = m \cdot g - Q_1 \cdot E = 0.045 \cdot 10^{-3} \text{ kg} \cdot 9.81 \frac{\text{N}}{\text{kg}} - 130 \frac{\text{N}}{\text{C}} \cdot 1.9 \cdot 10^{-6} \text{ C} = 1.94 \cdot 10^{-4} \text{N}$
   s = 0.50 m (work is performed only parallel to the electric field lines, while movements in opposite directions cancel each other out)
   $W = F \cdot s = 1.94 \cdot 10^{-4} \text{ N} \cdot 0.50 \text{ m} = \underline{\underline{9.7 \cdot 10^{-5} \text{ J}}}$

   c) $m \cdot a = m \cdot g - Q \cdot E \Rightarrow m = \frac{Q \cdot E}{g - a} = \frac{5.3 \cdot 10^{-5} \text{ C} \cdot 130 \frac{\text{N}}{\text{C}}}{9.81 \frac{\text{m}}{\text{s}^2} - 4.97 \frac{\text{m}}{\text{s}^2}} = \underline{\underline{1.4 \text{ g}}}$