Exam Preparation: Electric Hazards, Currents and Magnetic Fields

Theory: Answer the questions and explain the concepts by heart

a) Vector/scalar
b) Give examples of scalars
c) Give examples of vectors
d) Voltage
e) What is the purpose of electric current?
f) Direct current
g) Alternating current
h) Magnetic field
i) Work
j) Energy
k) Power
l) Efficiency
m) How much current (for how long) flowing through the human body is usually lethal?
n) Give three safety features that protect us from electric hazards. Explain how they work.
o) What is a short circuit? What happens to the current if a short circuit occurs?
p) What does the magnetic field of a current look like? Describe or draw.
q) What does the magnetic field of a current carrying coil look like? Describe or draw.
r) In what way does the magnetic field in a current-carrying coil change, if an iron core is introduced into it? Why?
s) Give examples of electromagnets

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

	symbol	unit		symbol	unit
time			displacement		
velocity			acceleration		
force			mass		
radius, distance			length		
work			power		
energy			internal energy		
voltage			charge		
electric current			resistance		
electric field strength			magnetic field strength		

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

Skills:

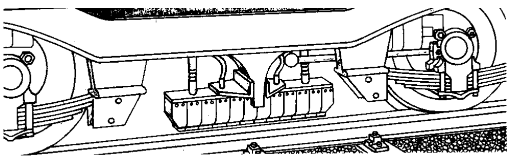
- Transform equations, insert numbers with units into the equation, calculate results correctly
- Round your results to the correct number of significant digits and write your answer with a power of ten in the normalized scientific format
- Draw and read scientific graphs
- Draw and read electric field line patterns
- Draw and read magnetic field line patterns
- Convert the unit *Pascal* to *bar* and vice versa
- Convert the unit *kWh* to *J* and vice versa
- Convert the unit *eV* to *J* and vice versa
- Convert units for area and volume
- Draw and read electric circuit diagrams
- Make proper use of the "left-hand rule"
- Make proper use of the "three-finger rule"
- Explain how an electric motor works

Exercises:

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

All work sheets plus assignment sheets A54 – A56

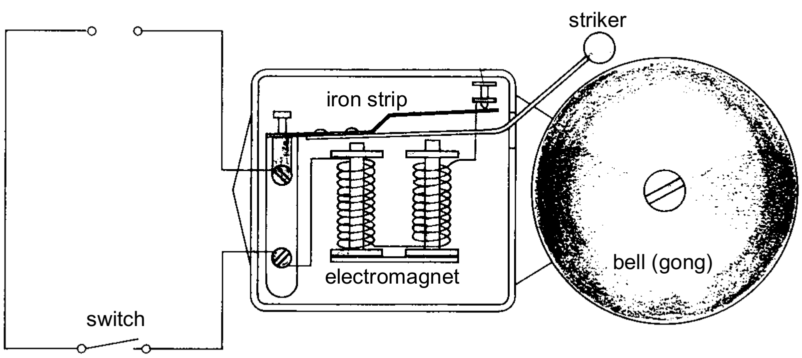
Additional problems

1. 

Streetcars have additional brakes using electromagnets (see picture).
Als long as they are not in use, they are held above the rails by a strong spring.
How does such a brake work?

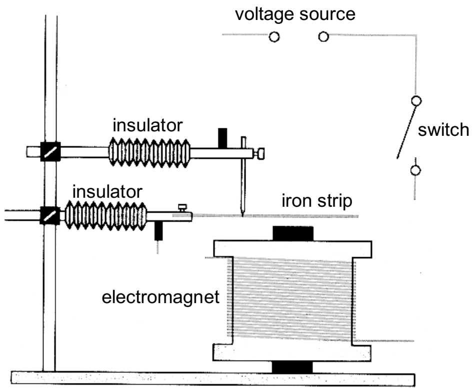
2. Here's an electric doorbell. The electromagnet of the electric bell repeatedly switches itself on and off very rapidly. Watch the animation until you understand how it works:

https://www.leifiphysik.de/elektrizitaetslehre/stromwirkungen/downloads/elektrische-klingel-animation

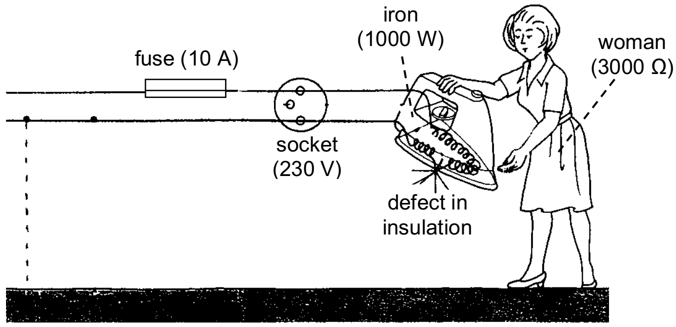


a) Draw the path of the current when the switch is closed. What is the purpose of the coil?
b) The iron strip is attached to the striker and can move up and down. Draw the position of the iron strip in the picture while a current passes through the coil of the electromagnet.
c) The iron strip is also attached to a contact where the electric circuit can be opened and closed. Draw in the picture where this contact is. What happens to the current in the electric circuit when the iron strip is in the position as described in b)?
d) What happens to the magnetic force of the electromagnet when the iron strip is in the position as described in b)?
e) As a consequence of d), what is the next position of the iron strip?
f) As a consequence of e), what happens to the current in the electric circuit?

3. Here's a schematic diagram of an electric doorbell.
a) Complete the picture. As long as the switch is closed, the iron sheet keeps moving up and down.
b) Draw the path of the current while the switch is closed.
c) Indicate the location of the contact where the electric circuit is opened and closed repeatedly.
d) Describe how the electric doorbell works. How does it continue? *"The button is pressed → the electric circuit is closed → a current passes through the coil of the electromagnet …* "

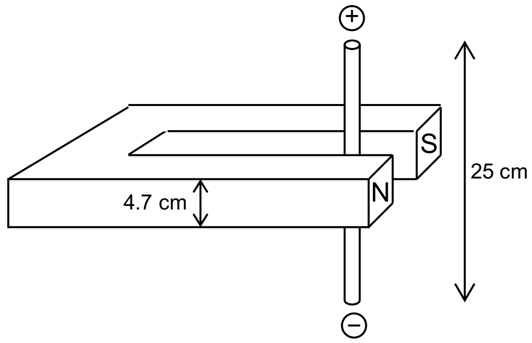


4. Here's an iron with a fuse. Due to a defect in insulation a current-carrying wire touches the metal case of the iron.
a) Draw the paths of all currents in the picture.
b) Calculate all currents (woman, iron, fuse).
c) Does the woman receive an electric shock? Give reasons for you answer.
d) Does the fuse blow?
e) What would happen if the iron was grounded?



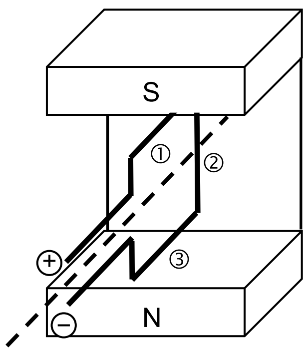
5. A wire of 0.08643900 km length is perpendicular to a magnetic field of 0.000210 mT. The force acting on the current is 1.67000 µN. The magnitude of the current is to be calculated.
a) Place a dot above the significant figures of the values which are required in the calculation. How many significant digits do they have? How many significant figures does your final answer require?
b) Calculate the magnitude of the current.
c) Round your results to the correct number of significant figures and write them in the normalized scientific notation (with a power of ten).

6. A current (I = 2.07 A) passes through a wire located between the poles of a horseshoe magnet. A force of 1.75 mN is acting on the electrons in the wire.
a) What is the direction of the magnetic force acting on the wire?
b) Calculate the magnetic field strength between the poles of the horseshoe magnet.

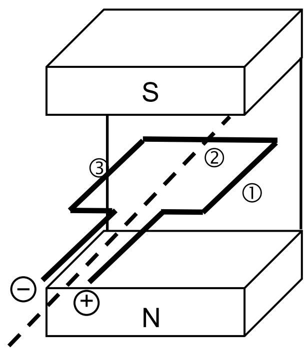


7. Here's a rectangular loop of wire in a magnetic field, mounted to rotate about the dashed axis. If a voltage is applied, electrons pass through the loop of wire.
Draw the direction of the magnetic force acting on the different parts of the wire. Does the loop of wire rotate? If yes, in what direction? If no, why not?

a)



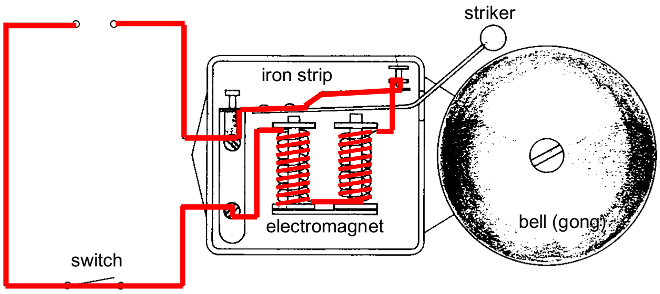
b)



Solutions:

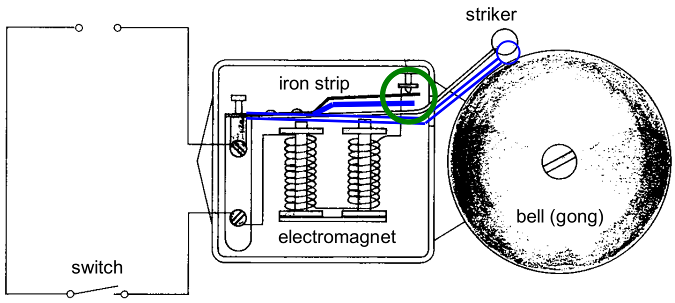
1. If a current passes through the electromagnet in the brake, it becomes magnetic and thus is attracted to the iron rail and pressed firmly onto the rail.

2. a)

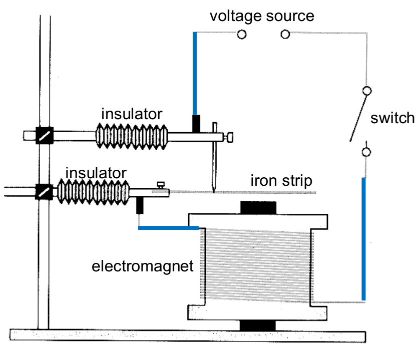


The coil is an electromagnet. It produces a magnetic field while a current passes through it.

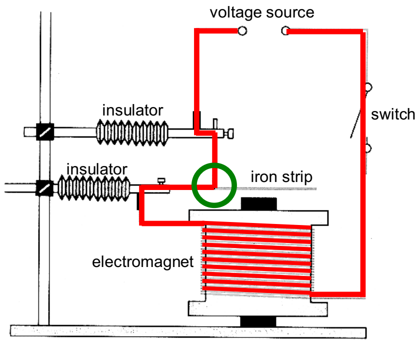
b) drawn in blue
c) drawn in green - the electric circuit is opened - no current
d) it no longer produces a magnetic field
e) the iron strip is no longer attracted, moves up and closes the contact.
f) The electric circuit is closed again - current flows.



3. a)

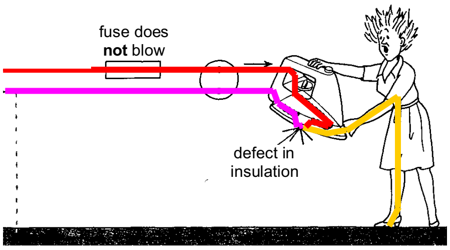


b) drawn in red
c) drawn in green



d) The button is pressed → the electric circuit is closed → a current passes through the coil of the electromagnet → the electromagnet produces a magnetic field → the iron strip is attracted by the electromagnet and moves down → the iron strip no longer touches the contact → the electric circuit is interrupted at the contact → no current passes through the coil of the electromagnet → the electromagnet no longer produces a magnetic field → the sheet of iron is no longer attracted, moves back up and touches the contact → the electric circuit is closed again → a current passes through the coil of the electromagnet → the electromagnet produces a magnetic field → the iron strip is attracted by the electromagnet and moves down → etc.

4. a)



b) $I_{\text{woman}} = \dfrac{U}{R_{\text{woman}}} = \dfrac{230\text{ V}}{3'000\ \Omega} = \underline{\underline{0.077\text{ A}}}$ $\qquad I_{\text{iron}} = \dfrac{P_{\text{iron}}}{U} = \dfrac{1000\text{ W}}{230\text{ V}} = \underline{\underline{4.35\text{ A}}}$

$I_{\text{fuse}} = I_{\text{total}} = I_{\text{iron}} + I_{\text{woman}} = 4.35\text{ A} + 0.077\text{ A} = \underline{\underline{4.42\text{ A}}}$

c) Yes, the current through the woman is 77 mA, which is more than 50 mA (= death)

d) No; Current through the fuse: 4.35 A. The fuse only blows over 10 A.

e) The excess current would flow through the ground wire and the woman would not receive an electric shock. Due to a large increase in current the fuse would blow.

5. a) $B = 0.000\dot{2}\dot{1}\dot{0}$ mT: 3 significant figures, $\ell = 0.0\ \dot{8}\dot{6}\dot{4}\dot{3}\dot{9}\dot{0}\dot{0}$ km: 7 significant figures,

$F = \dot{1}.\dot{6}\dot{7}\dot{0}\dot{0}\dot{0}$ µN: 6 significant figures; result: 3 figures

b) $I = \dfrac{F}{\ell \cdot B} = \dfrac{1.67000 \cdot 10^{-6}\ \text{N}}{0.0864390 \cdot 10^{3}\ \text{m} \cdot 0.000210 \cdot 10^{-3}\ \text{T}} = 0.09199992\text{ A} = \underline{\underline{0.0920\text{ A}}}$

c) $\underline{\underline{9.20 \cdot 10^{-2}\text{A}}}$

6. a) to the right $\qquad$ b) $B = \dfrac{F}{I \cdot s} = \dfrac{1.75 \cdot 10^{-3}\ \text{N}}{2.07\text{ A} \cdot 0.047\text{ m}} = 0.0180\text{ T} = \underline{\underline{18.0\text{ mT}}}$

7. a) ① to the right, ② no magnetic force, ③ to the left. The loop of wire rotates clockwise.

b) ① to the right, ② to the back, ③ to the left. The loop of wire does not rotate, because the forces point outwards and cannot move the loop of wire.