Exercise „Electromagnetism“

Problem example:

What is the kinetic energy of an electron moving in circular trajectory with radius of r = 10 cm between the two poles of an electromagnet which produces a homogeneous magnetic field of B = 1 T. The plane of the circular motion is perpendicular to the magnetic force lines. The mass of the electron is 9.11×10^{-31} kg.

Solution:

The kinetic energy of a moving body is given by the formula:

$$E_k = \frac{1}{2}mv^2$$

We must calculate the electron velocity at first. The magnetic force of the magnetic field exerted on the electron must be equal to the centripetal force (the electron is on a circular path):

$$F = BevsinΘ = Bev = m\cdot\frac{v^2}{r} \qquad (sinΘ = 1)$$

The last term is the centripetal force. After rewriting:

$$v = \frac{Ber}{m}$$

thus:

$$E_k = \frac{1}{2}mv^2 = \frac{B^2e^2r^2}{2m}$$

Result: After substitution and calculation we obtain 1.39×10^{-16} J. Our electron moves with velocity of 1.75×10^{7} km.s^{-1}!!!!

Is there some problem?

1. A conductor passed by electric current is placed in magnetic field of B = 2 T. The 50 cm long conductor is oriented normally to the vector B. The force acting on the conductor equals to 10 N. What is the value of the electric current?

2. A conductor passed by electric current of 1 A is placed in magnetic field of magnetic flux density B = 2 T. The conductor is oriented normally to the vector B, and its length equals 20 cm. What is the force acting on the conductor?

3. An “infinite” wire is passed by an electric current of 5 A. What is the vector B magnitude in distance of 1 m from the wire? ($\mu_0 = 4\pi\cdot10^{-7}$ N·A^{-2})

4. An “infinite” wire is passed by an electric current of 5 A. What is the distance in which the value of B will be 1 T? ($\mu_0 = 4\pi\cdot10^{-7}$ N·A^{-2})

5. What is the force acting between two 1 m long parallel conductors (wires) 1 cm apart? Electric current intensity in both conductors is always 10 A. ($\mu_0 = 4\pi\cdot10^{-7}$ N·A^{-2})

6. What is the voltage induced in a 30 cm long conductor moving at a velocity of 20 $m.s^{-1}$ and oriented normally to the vector of B = 0.2 T? The magnetic field is homogeneous.

7. What is the voltage induced in a single wire loop (one turn of a solenoid) of diameter 10 cm after switching on a homogeneous magnetic field (B = 0.1 T) during 1 ms. Assume that the B value increases linearly during this time. The wire loop is placed in vacuum. The plane of the loop is perpendicular to the B vector.

T1. Two parallel insulated conductors carry electric current of the opposite direction. Thus
a) they are attracted.
b) they are repulsed.
c) they are repulsed only at switching current on.
d) there is no repulsion or attraction when using alternating current.
e) No answer is correct.

T2. Magnetic force exerted on a conductor carrying electric current in a magnetic field must be equal to zero when:
a) the current is alternating
b) the angle made by the conductor and vector of magnetic flux density equals 90^o
c) the angle made by the conductor and vector of magnetic flux density equals 0^o
d) the magnetic force lines are not parallel
e) No answer is correct.

T3. The magnetic flux density inside an infinite solenoid (inductor) is:
a) directly proportional to the radius of the solenoid
b) indirectly (inversely) proportional to the total number of turns
c) indirectly proportional to the magnetic permeability of medium
d) equal to zero (there is no magnetic field)
e) No answer is correct.

T4. The magnetic flux density B inside (in the middle) of a circular coil under electric current is:
a) directly proportional to the coil radius
b) indirectly (inversely) proportional to the number of turns
c) directly proportional to the magnetic permeability of medium
d) equal to zero (there is no magnetic field)
e) No answer is correct.

T5. Let us have a circular wire (a loop) with electric current. What is the change of magnetic flux density B in the centre of the loop if its radius increased two-times (the current is constant)?
a) no change
b) lowered to one half $B = \mu I/2r$
c) lowered to one fourth
d) increased twice
e) No answer is correct.

T6. Imagine that electric current passes the conductor which is normal to this paper sheet. The electrons move "into the paper". What will be the direction of (the vector of) magnetic flux density produced?

a) the same as direction of electron movement
b) clockwise viewed along the direction of electron movement
c) opposite to the direction of electron movement
d) anti-clockwise viewed along the direction of electron movement
e) No answer is correct.

T7. If a nucleus of hydrogen starts to move in a homogeneous magnetic field perpendicularly to the vector of magnetic flux density B, then the nucleus will
a) be slowed down in its rectilinear motion.
b) be accelerated in its rectilinear motion.
c) bend its trajectory towards the south magnetic pole.
d) start to move in circles in this field.
e) No answer is correct.

T8. If an ion enters homogeneous magnetic field in parallel to its lines of force in direction of $N \rightarrow S$, it
a) will be uniformly decelerated.
b) will be uniformly accelerated.
c) will move in direction indicated by the thumb of the left hand, which fingers point in direction of the ion movement.
d) will move in direction indicated by the thumb of the right hand, which fingers point in direction of the ion movement.
e) No answer is correct.

Alternating current

1. What is the effective value (i.e. RMS value) of voltage, which “peak to peak” value of voltage equals 20 V?

2. What is the "peak" value of mains voltage (i.e. its amplitude), which effective (i.e. root mean square) value equals 230 V?

3. The frequency of alternating electric current is 50 Hz. In what time (after switching on the source) the peak voltage will be reached?

4. The reactance of a capacitor in an electric circuit is 1 kΩ, the frequency of electric current equals 100 kHz. What is the capacitance of this capacitor?

5. The reactance of a capacitor in an electric circuit is 1 kΩ, its capacitance equals 1 nF. What is the frequency of electric current?

T1. Electric power of alternating current can be calculated according to the formula P = U.I only when:
a) both U and I are given in peak values
b) both U and I are given as their amplitudes
c) both U and I are given in effective (RMS) values
d) This formula cannot be used at all.
e) No answer is correct.

T2. The phase shift between two electric signals of sinusoidal time-course and identical frequency is π. It means that, at the same time:
a) both signals reach maximum value
b) both signals reach minimum value
c) one signal has its maximum value, the second one has zero value
d) one signal has its maximum value, the second one has its minimum value
e) No answer is correct.

T4. Find the right formula for reactance of a capacitor
a) $X_C = Q/U$ b) $X_C = \omega C$ c) $X_C = \omega/C$ d) $X_C = 1/\omega C$
e) No answer is correct.

T5. The unit "ohm" is used for:
a) self-inductance, resistance and resistivity
b) self-inductance, capacitance and resistance
c) self-inductance, capacitance and conductivity
d) resistance and reactance
e) No answer is correct.

T6. The impedance of an AC circuit consisting of only one coil increases when
a) decreasing the self-inductance of the coil.
b) increasing the self-inductance of the coil.
c) connecting a resistor parallelly
d) lowering the frequency of AC.
e) No answer is correct.

T7. The impedance of an AC circuit consisting of only one capacitor decreases when
a) increasing the capacitor capacitance.
b) decreasing the capacitor capacitance.
c) lowering the frequency of AC.
d) connecting a resistor in series.
e) No answer is correct.

T8. Alternating electric current of very high frequency passes through a capacitor, but:
a) poorly
b) only its positive half-waves
c) only its negative half-waves
d) only if a good insulator is used in the space between the plates

e) No answer is correct.

T9. What physical quantities have the same unit?
a) self-inductance, resistance and resistivity
b) resistance, conductance and capacitance
c) self-inductance, capacitance and conductivity
d) reactance and resistance
e) No answer is correct.

T10. Some resonance occurs in an electric circuit with a coil and a capacitor in series if
a) the reactances of the capacitor and the coil are of the same magnitude.
b) the reactance of the capacitor is negligible in comparison with the reactance of the coil.
c) the reactance of the coil is negligible in comparison with the reactance of the capacitor.
d) In such a circuit any resonance is impossible.
e) No answer is correct.