Exam-03

1. A high-power transmission line carries a single wire through which flows a current of magnitude 1000 A. A house is located at a distance of 10 m from the transmission line.
   (a) Calculate the *H*-field and *B*-field at the house and compare it to the Earth's magnetic field (B_{Earth} = 50 μT)
   (b) How close would a compass need to be to the power line so that a compass would no longer reliably show the North and South direction of the Earth?

2. A densely wound long helical coil, also called solenoid, has a radius r = 1 cm, a length of ℓ = 20 cm, and N = 200 windings. The 1st half of the solenoid (ℓ_1 = ½ ℓ) is filled with a magnetic core made of an iron alloy (μ_r = 1 000). The 2nd half of the solenoid (ℓ_2 = ½ ℓ) is filled with air.
   (a) Draw the experimental setup. And assume that the solenoid is injected with a current of I = 1.5 A. Starting with Maxwell's 4th equation, derive a symbolic expression for the magnetic *H*-field and *B*-field in each of the two regions of the solenoid.
   (b) Calculate the *H*-field and *B*-field (numerical values) in each of the two regions.
   (c) Calculate the inductance of the solenoid. The inductance is defined by the equation $V_{\text{ind}} = L\,\dot{I}$.

   Next, a 2nd identical magnetic core is added to the 1st core, thereby filling the entire inner space of the solenoid.
   (d) Derive an expression for the force by which the 2nd core interacts with the 1st core.
   (e) Is the force attractive or repulsive? Calculate the force (numerical value).

3. A transformer has a core metal loop made of a ferroelectric with μ_r = 1 000, a loop length of ℓ = 0.5 m and a cross section of A = 0.005 m^2. The transformer is used to convert V_1 = 10 kV to V_2 = 120 V with a secondary current of I_2 = 100 A.
   (a) What is the winding ratio of the transformer? What is the approximate value of the primary current?
   (b) Which of the two windings, primary or secondary, typically uses wire with a greater cross section? Why?
   (c) The primary number of windings, N_1, is chosen so that the *B*-field in the transformer's core is equal to the core's residual magnetic flux density with B_{residual} = 1.0 T. Determine N_1. Determine N_2.
   (d) Explain as to why the magnetic flux density should not exceed B_{residual}.

4. Determine if the following statements are (i) true, (ii) false, or (iii) impossible to determine due to lack of information. Explain each of your answers with a few words.
   (a) An ideal inductor can be injected with a current without a voltage dropping across the inductor.
   (b) Magnetic flux leakage in a transformer will reduce the secondary voltage and increase the secondary current.