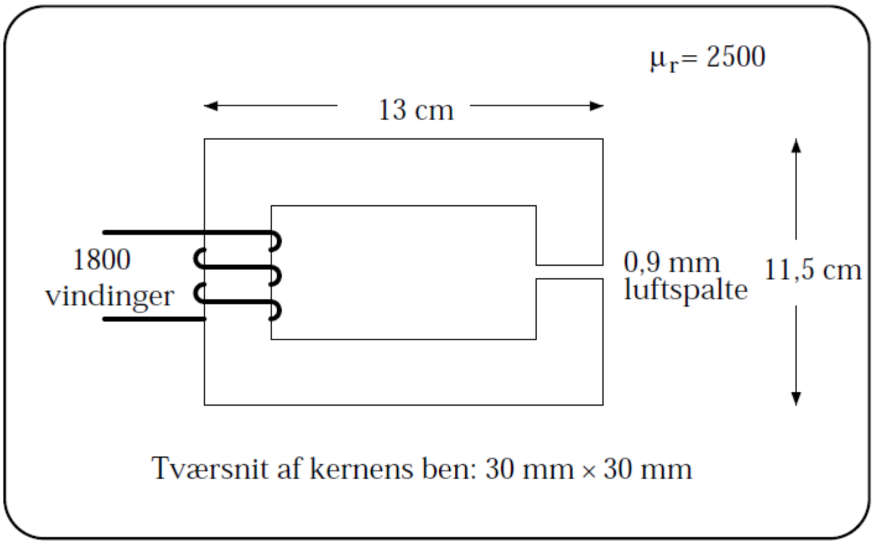
Exercise 6.1

The figure shows a transformer that is to be used in a power supply. The relative permeability of the core is 2500, and the core can be considered linear.



a. Draw a magnetic equivalent diagram for the transformer and calculate the reluctance of the air gap and the iron core. Consider an area increase of $\frac{2\ell}{\sqrt{A}}$ in the air gap, l is the length of the air gap, A is the actual area.

b. Determine the magnetic flux in the iron core when a current of 475 mA flows in the winding.

c. Calculate the magnetic voltage drop across the iron core and the air gap, respectively.

d. Determine the magnetic field strength (H-field) in the iron core and the air gap, respectively.

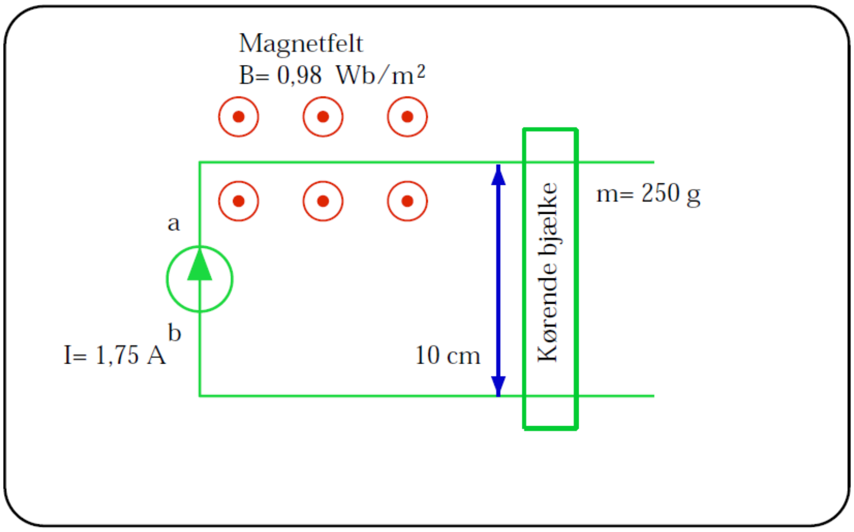
e. Calculate the "necessary flux" found in the core when the transformer is connected to a sinusoidal voltage of 230 V (effective), 50 Hz.

Exercise 6.2

The beam shown in the figure can move on the rails to the right and left without significant friction. The rails are as long as necessary (infinitely long). The beam is electrically conductive.

The beam is at rest at time t = 0 s. After t = 0 s, the current generator supplies a current of 1.75 A in the direction shown. The magnetic field of 0.98 Wb/m2 is in the direction shown in figure (out of the paper).

The beam is 10 cm long and has a mass of 250 g.



a. What is the force that is applied to the beam after t = 0 s? Indicate the magnitude and the direction as either right or left.

b. Calculate the beam's acceleration.

c. After 2.1 seconds, the beam is slowed down by an external force so that the speed becomes constant. What is the speed, and how large must the external force be?

d. What is the magnitude of the mechanical power required to keep the beam's speed constant?

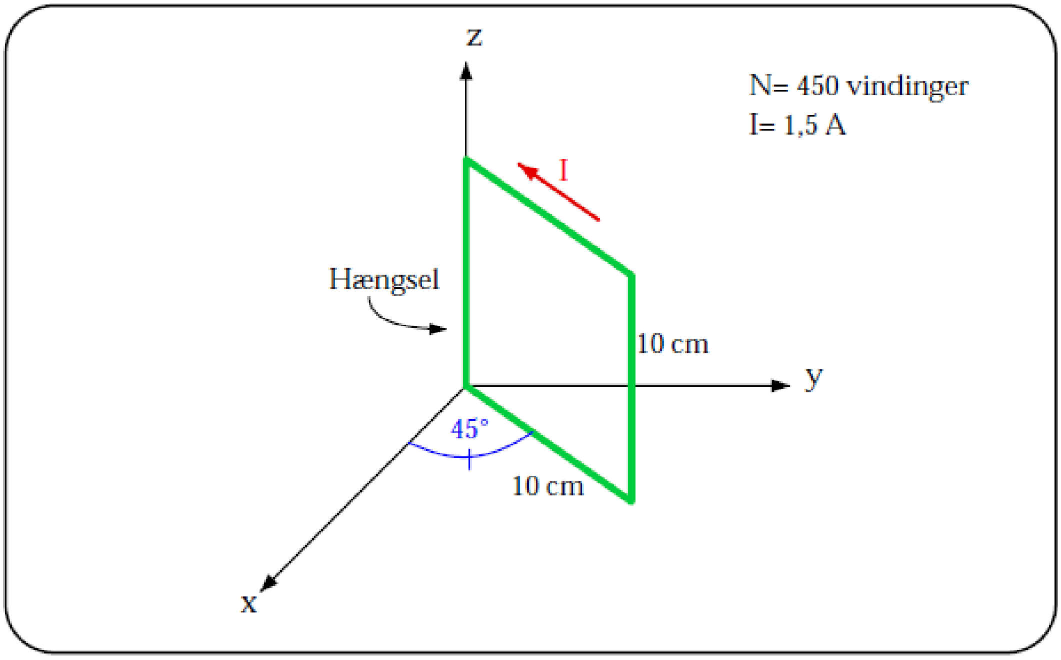
e. What will be the voltage across the current generator?

f. Does point a in the drawing become positive in relation to point b, or vice versa? Indicate a as plus or minus.

Exercise 6.3

The green frame in the figure is a coil with 450 turns and dimensions 10 x 10 cm as shown. The frame is hinged so that it can rotate around the z-axis. The current through the coil is 1.5 A in the direction shown in figure (the red arrow). There is a magnetic field in the area, given by:

$$B = \begin{bmatrix} 0 \\ 0.32 \\ 0.15 \end{bmatrix} \quad \mathrm{Wb/m^2}$$



a. Calculate the magnetic dipole moment of the loop. The answer should be given as a three-dimensional vector. (Remember to include the direction of the current).

b. Calculate the torque the loop is subjected to.

c. Will the frame rotate around the z-axis when the current is connected? If so, which way? (clockwise or counterclockwise).

Exercise 6.4

We consider two point charges in a rectangular (x, y, z) coordinate system in empty space. Remember to provide the answers with correct units.

The charges are:

Q1: +10/9 nC at (x, y, z) = (2, 2, 1) m

Q2: -20/9 nC at (x, y, z) = (-1, -1, -1) m

a. Sketch the configuration of charges.

b. Determine the electric field vector at point A: (x, y, z) = (0, 0, 0).

c. Calculate the D-field (electric displacement field) at point A (The D-field should be given as a vector).

d. Calculate the absolute electric potential at point A.

e. Now, a spherical surface is inserted in the coordinate system. The sphere has a radius of 2 m and center at (0,0,0). Determine the value of the total flux of the D-field out through the spherical surface. You can use a method of your choice for the calculation.

f. Calculate the magnitude of the force acting between the two charges Q1 and Q2. Indicate attraction or repulsion.