

Block 17 — Magnetic Flux Density and Forces

Student Group

First Name	Surname	Matrikel Nr.

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Block xx - xxx

Learning objectives

After this 90-minute block, you can

- ...

Preparation at Home

Well, again

- read through the present chapter and write down anything you did not understand.
- Also here, there are some clips for more clarification under 'Embedded resources' (check the text above/below, sometimes only part of the clip is interesting).

For checking your understanding please do the following exercises:

- ...

90-minute plan

1. Warm-up (x min):
 1.
2. Core concepts & derivations (x min):
 1. ...
3. Practice (x min): ...
4. Wrap-up (x min): Summary box; common pitfalls checklist.

Conceptual overview

1. ...

Core content

...

Common pitfalls

- ...

The magnitude of the magnetic field strength H can be calculated by: $H = \frac{I}{2\pi \cdot r}$

So, we get for H_{i} at $r_{\text{i}} = 0.1 \text{ mm}$, and H_{o} at $r_{\text{o}} = 0.55 \text{ mm}$:

$$\begin{aligned} H_{\text{i}} &= \frac{I}{2\pi \cdot r_{\text{i}}} = \frac{+3.3 \text{ A}}{2\pi \cdot 0.1 \cdot 10^{-3} \text{ m}} \\ H_{\text{o}} &= \frac{I}{2\pi \cdot r_{\text{o}}} = \frac{+3.3 \text{ A}}{2\pi \cdot 0.55 \cdot 10^{-3} \text{ m}} \end{aligned}$$

Hint: For the direction, one has to consider the right-hand rule. By this, we see that the H -field on the right side points downwards.

Therefore, the sign of the H -field is negative.

But here, only the magnitude was questioned!

Exercise E3 Magnetic Flux Density

(written test, approx. 6 % of a 120-minute written test, SS2021)

A) The inductor is operated for experiments in the laboratory. A current $I = 100 \text{ A}$ with an amplitude of $\hat{I} = 100 \text{ A}$ is operated.

Now stand back and think about what this value means! (3 points, independent)

The figure below shows the top view of the laboratory with the supply line between A and B .

Path $B = 0.2 \text{ m}$

$\mu_0 = 4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}}$, $\mu_r = 1$

The formula for the magnetic field strength can be rearranged: $H = \frac{I}{2\pi \cdot r}$

Again, the magnetic flux density B is given as: $B = \mu_0 \mu_r H$

Therefore: $r = \frac{\mu_0 \mu_r I}{2\pi B} = \frac{4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}} \cdot 100 \text{ A}}{2\pi \cdot 100 \cdot 10^{-6} \text{ T}}$

a) What is the highest magnetic flux density through the line in your body? (3 points)

Path

The magnetic field strength for a conducting wire is given as:

$$H = \frac{I}{2\pi \cdot r}$$

The magnetic flux density B is given as: $B = \mu_0 \mu_r H$

Here, the maximum current is $\hat{I} = 100 \text{ A}$ and the distance to the cable is $r = \sqrt{(0.1 \text{ m})^2 + (0.4 \text{ m})^2} = 0.412... \text{ m}$.

$$\text{Therefore: } B = 4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}} \cdot 1 \cdot \frac{100 \text{ A}}{2\pi \cdot 0.412... \text{ m}}$$

Exercise E4 Toroidal Coil**(written test, approx. 5 % of a 120-minute written test, SS2021)**

A magnetic field with a flux density of at least 50 mT is to be achieved in a ring-shaped coil (toroidal coil).

The coil has 60 turns, wound around soft iron with $\mu_r = 1200$.

The average field line length in the coil should be $l = 12 \text{ cm}$.

Result: $I_{\text{min}} = 4 \text{ A}$



What is the minimum current that must flow through a single winding?

Path

The magnetic field strength of a toroidal coil is given as:

$$\begin{aligned} H &= \frac{N \cdot I}{l} \end{aligned}$$

Based on the flux density the magnetic field strength can be derived by $B = \mu_0 \mu_r \cdot H$.

By this, the formula can be rearranged:

$$\begin{aligned} H &= \frac{N \cdot I}{l} \quad \parallel \quad \frac{B}{\mu_0 \mu_r} = \frac{N \cdot I}{l} \quad \parallel \quad I = \frac{B \cdot l}{\mu_0 \mu_r \cdot N} \end{aligned}$$

Putting in the numbers:
$$I = \frac{0.05 \text{ T} \cdot 0.12 \text{ m}}{4\pi \cdot 10^{-7} \frac{\text{Vs}}{\text{Am}} \cdot 1'200 \cdot 60} = 0.6631... \frac{\text{T} \cdot \text{m}}{\frac{\text{Vs}}{\text{Am}}} = 0.6631... \frac{\text{Vs}}{\text{m}^2} \cdot \text{m} \cdot \frac{\text{Am}}{\text{Vs}} = 0.6631... \text{ A}$$

Embedded resources

Explanation (video): ...

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