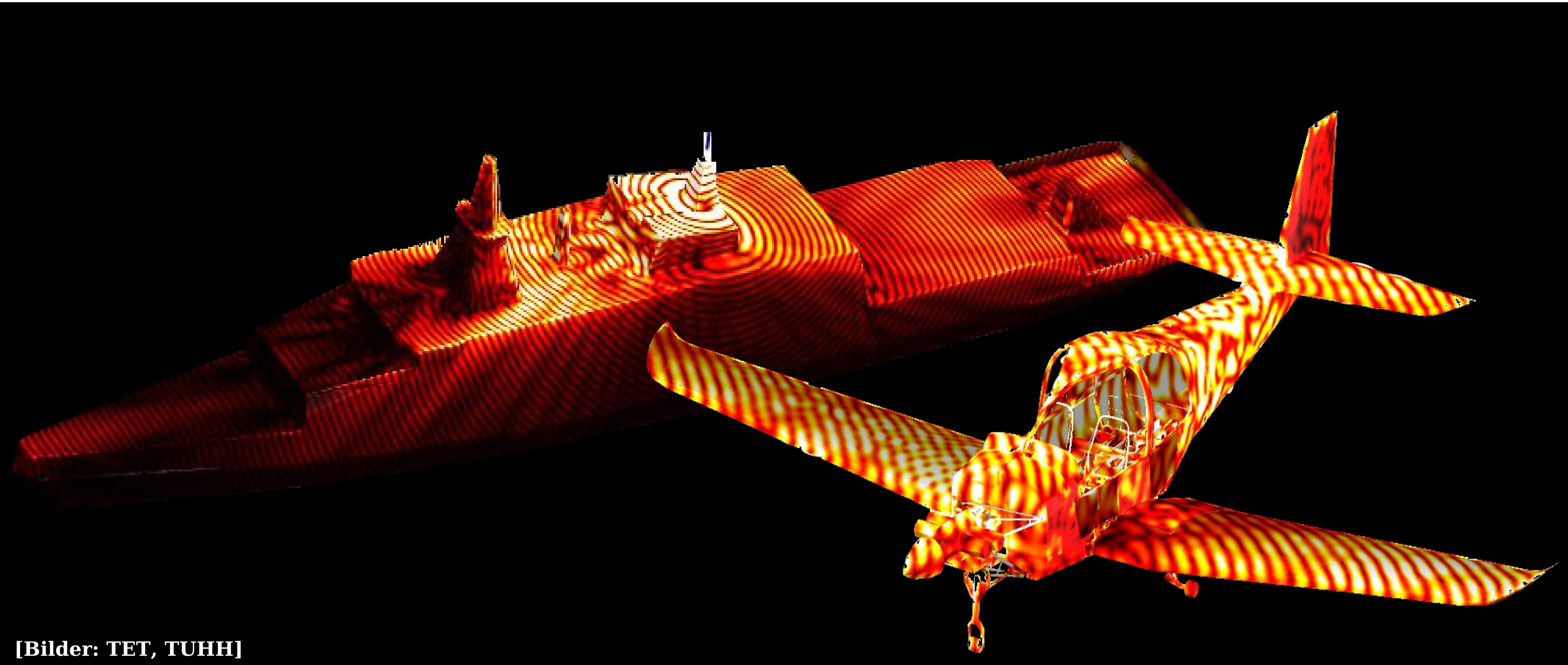
Electromagnetics for Engineers I: Time-Independent Fields

Dr. Cheng Yang, Prof. Dr. sc. techn. Christian Schuster

Course Overview, Summer Term 2023



[Bilder: TET, TUHH]

What the TET is about?

TET = Theoretische Elektrotechnik (German)

= Network and electromagnetic field theory (earlier)

= Electromagnetic field theory (today)

≈ Maxwell’s Field Theory

Maxwell's field theory or the corresponding equations describe the behavior of electromagnetic fields at a macroscopic level.

The calculation, evaluation and dimensioning are the tasks of electromagnetic field theory .

Curriculum

Week	Topics	Chapter Script	Chapter Henke
1	Introduction, Overview, Repetition, Vector Fields and Integrals	1.1	
2	Maxwell-Equations (ME) in integral Form, Vector Analysis	1.1	2.1 – 2.8
3	Coordinate Systems, ME in differential Form and Conclusions	1.3 – 1.7	1.1 – 1.4, 2.9, 2.10, 4.3, 7.6, 9.3
4	**MATLAB:** Introduction and Dealing with Fields		
5	Fundamentals of Electrostatics, main Solution Methods	2.1	3.1 – 3.7
6	Main Solution Methods (continued), Partial Capacitance	2.2	3.8
7	Partial Capacitance (continued), **MATLAB**: Electrostatic Fields		
8	Conformal Mappings, Separation of Variables	2.2	6.3, 6.2
9	Separation of Variables (continued)		
10	Magnetostatics, Magnetization, analogy to Electrostatics	2.3	9.1 – 9.2
11	Electric Current Density Fields, analogy to Electrostatics	3.1	7.1 – 7.6
12	**MATLAB:** Finite difference Method for static Fields		6.4
13	Magnetic Fields of steady Currents, Ampere's law	3.2	8.1, 8.2
14	Mag. Vector Potential, Biot-Savart Law, Poynting Vector	3.2 – 3.5	8.3 – 8.6
15	Exam Preparation		

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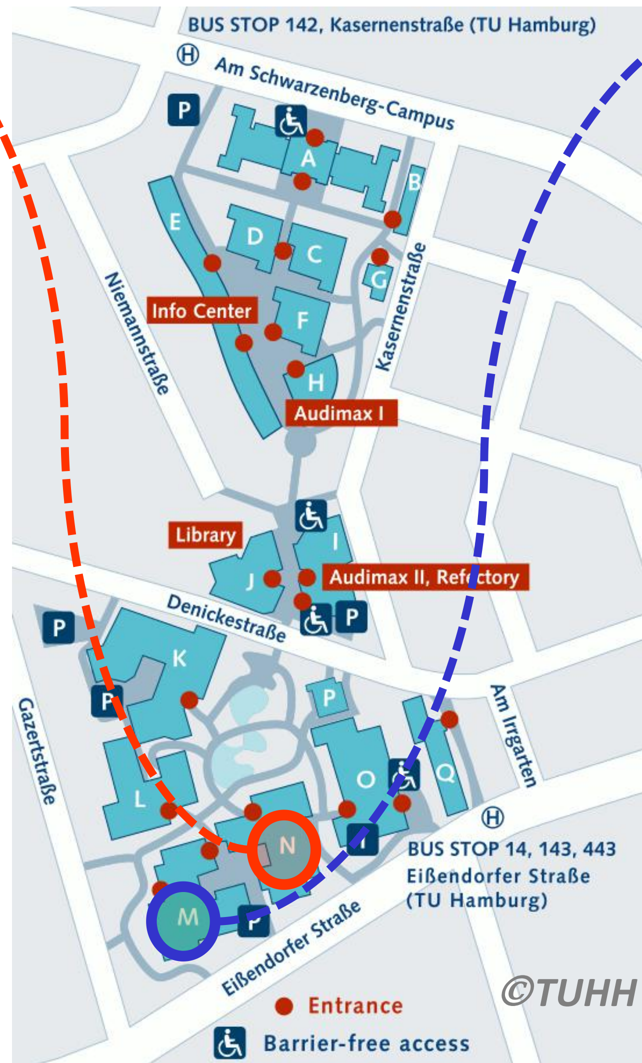
Friday 11:30-13:45, N-007, 14.07

TET
Theoretische Elektrotechnik

Schedule

Lecture: N-007

Time ▲
Fri., 14/04/23, 11:30 - 13:45
Fri., 21/04/23, 11:30 - 13:45
Fri., 28/04/23, 11:30 - 13:45
Fri., 05/05/23, 11:30 - 13:45
Fri., 12/05/23, 11:30 - 13:45
Fri., 26/05/23, 11:30 - 13:45
Fri., 02/06/23, 11:30 - 13:45
Fri., 09/06/23, 11:30 - 13:45
Fri., 16/06/23, 11:30 - 13:45
Fri., 23/06/23, 11:30 - 13:45
Fri., 30/06/23, 11:30 - 13:45
Fri., 07/07/23, 11:30 - 13:45
Fri., 14/07/23, 11:30 - 13:45



Exercise: M-1582

Time ▲
Thu., 13/04/23, 11:30 - 13:00
Thu., 20/04/23, 11:30 - 13:00
Thu., 27/04/23, 11:30 - 13:00
Thu., 04/05/23, 11:30 - 13:00
Thu., 11/05/23, 11:30 - 13:00
Thu., 25/05/23, 11:30 - 13:00
Thu., 01/06/23, 11:30 - 13:00
Thu., 08/06/23, 11:30 - 13:00
Thu., 15/06/23, 11:30 - 13:00
Thu., 22/06/23, 11:30 - 13:00
Thu., 29/06/23, 11:30 - 13:00
Thu., 06/07/23, 11:30 - 13:00
Thu., 13/07/23, 11:30 - 13:00

Goals of this Course

Students can explain the fundamental formulas, relations, and methods of the theory of time-independent electromagnetic fields. They can explicate the principal behavior of **electrostatic**, **magnetostatic**, and **current density fields** with regard to respective sources. They can describe the properties of **complex electromagnetic fields** by means of **superposition** of solutions for simple fields. The students are aware of applications for the theory of time-independent electromagnetic fields and are able to explicate these.

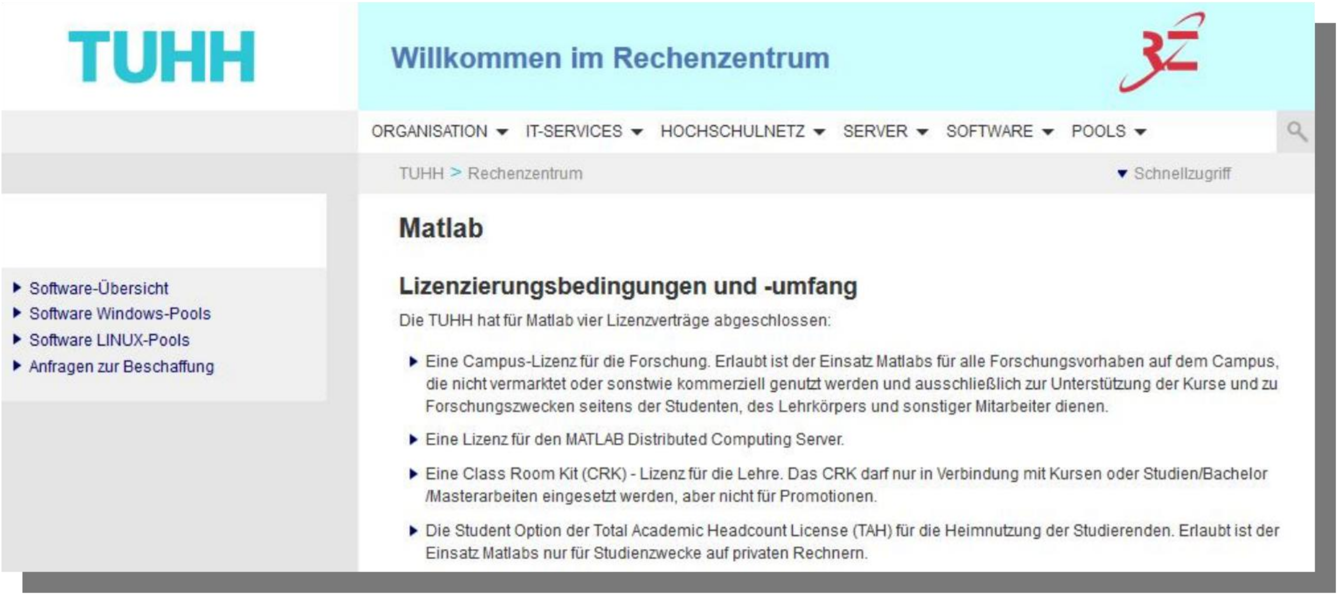
Furthermore, they are capable of applying a variety of methods that require solving Maxwell's Equations in both **integral** and **differential** notations for more general problems. The students can assess the principal effects of given time-independent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the **characterization** of electrostatic, magnetostatic, and electrical flow fields (**capacitances**, **inductances**, **resistances**, etc.) from given fields and dimension them for practical applications.

MATLAB-Units

MATLAB is required for working interactively in three lectures (and possibly also exercises). For these units, students should be in groups of max two participants per one portable computer with MATLAB pre-installed.

Information about installation and license conditions at TUHH can be found at:

https://www.tuhh.de/rzt/software/numerik/matlab.html



Exercise

All exercises are as "presence exercises", i.e. students should work on the given problems /tasks independently as far as possible under the guidance of the tutor in course.

Group discussions are expressly encouraged.

Exemplary solutions are available on Stud.IP.

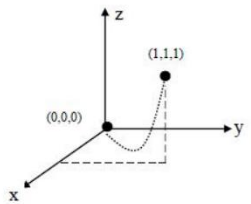
Sommersemester 2018

Präsenzübung zur Theoretischen Elektrotechnik

\- Integration im Raum -

Berechnen Sie die folgenden Kurven- und Flächenintegrale! Überlegen Sie, welche physikalische Bedeutung jedes Integral haben könnte!

1. $\int_{(0,0,0)}^{(1,1,1)} \vec{F} \cdot d\vec{r}$ mit $\vec{F} = \begin{pmatrix} xy^2z^2 \\ x^2yz^2 \\ x^2y^2z \end{pmatrix}$



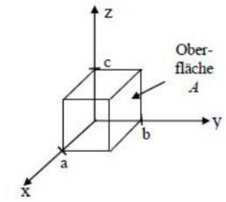
auf den beiden Wegen $(0,0,0) \rightarrow (1,0,0) \rightarrow (1,1,0) \rightarrow (1,1,1)$ und

$$\vec{r} = \vec{r}(t) = \begin{pmatrix} t \\ t^2 \\ t^3 \end{pmatrix}, \; t \in [0,1]$$

Hinweis: für den zweiten Weg empfiehlt sich eine Umformung des Integranden gemäß $\vec{F} \cdot d\vec{r} = \vec{F} \cdot (d\vec{r}/dt) \cdot dt$ mit entsprechender Berücksichtigung der Integrationsgrenzen.

Vergleichen Sie die Ergebnisse der beiden Wege! Können Sie zeigen, dass das Integral wegunabhängig ist (für jeden Weg denselben Wert annimmt)?

2. $\oiint_A \vec{D} \cdot d\vec{A}$ mit $\vec{D} = \rho_0 \cdot \begin{pmatrix} x \\ z \\ y \end{pmatrix}$



mit $\rho_0 =$ konstant und der geschlossenen Oberfläche A gemäß nebenstehender Skizze.

Gibt es eine andere, einfachere Möglichkeit, dieses Integral zu berechnen?

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Script

The Institute of Electromagnetic Theory offers students a free script (hard copy)

At the beginning of the lecture, a limited number of scripts will be brought.

After that, please make an individual appointment with Mrs. Usta (pelin.usta@tuhh.de) to get your script.


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Institut für
Theoretische Elektrotechnik

Skriptum

Theoretische Elektrotechnik I + II

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TET

Literature

Close to the lecture, partially alternative textbooks:

- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer, 2011 (E-Book TUHH) – very close to the scripts!
- M. Filtz, H. Henke, "Übungsbuch Elektromagnetische Felder", Springer (E-Book TUHH) – good for exam preparation!
- G. Lehner, "Elektromagnetische Feldtheorie für Ingenieure und Physiker", Springer, 2010 (E-Book, TUHH) – detailed, suitable for self-learning!

For more physical application, please continue reading:

- W. Nolting, "Grundkurs Theoretische Physik 3 : Elektrodynamik" Springer, 2011 (E-Book TUHH)
- D. J. Griffiths, "Elektrodynamik: Eine Einführung", Pearson, 2012
- J. D. Jackson, “Klassische Elektrodynamik", Gruyter (E-Book, TUHH)

Written Exam

The written exam of Electromagnetics for Engineers usually takes 110-130 minutes and consists of two parts:

Part 1 = “Knowledge part” (10 Minutes)

Processing without any aids

Part 2 = “Application and analysis part” (remaining time)

Processing with written aids

(e.g. script, books, slide sets, etc.)

The first part would be collected before the second part is started.

Individual Exam Calculation

In addition to the course, an individual exam calculation is offered so that students can work on old written exams under examination conditions. The procedure is as follows: :

- Making appointment with the tutor of the exercise
- Arranging individual or multiple exam tasks(without time limit but only with the permitted aids) at the Institute of Electromagnetic Theory on the agreed date
- Correction and discussion directly with the tutor

The exam calculation has no direct influence on the grading of the final written exam, but it is only used for the improvement of their own abilities and their assessment.