Electromagnetics for Engineers II: Time-dependent Fields

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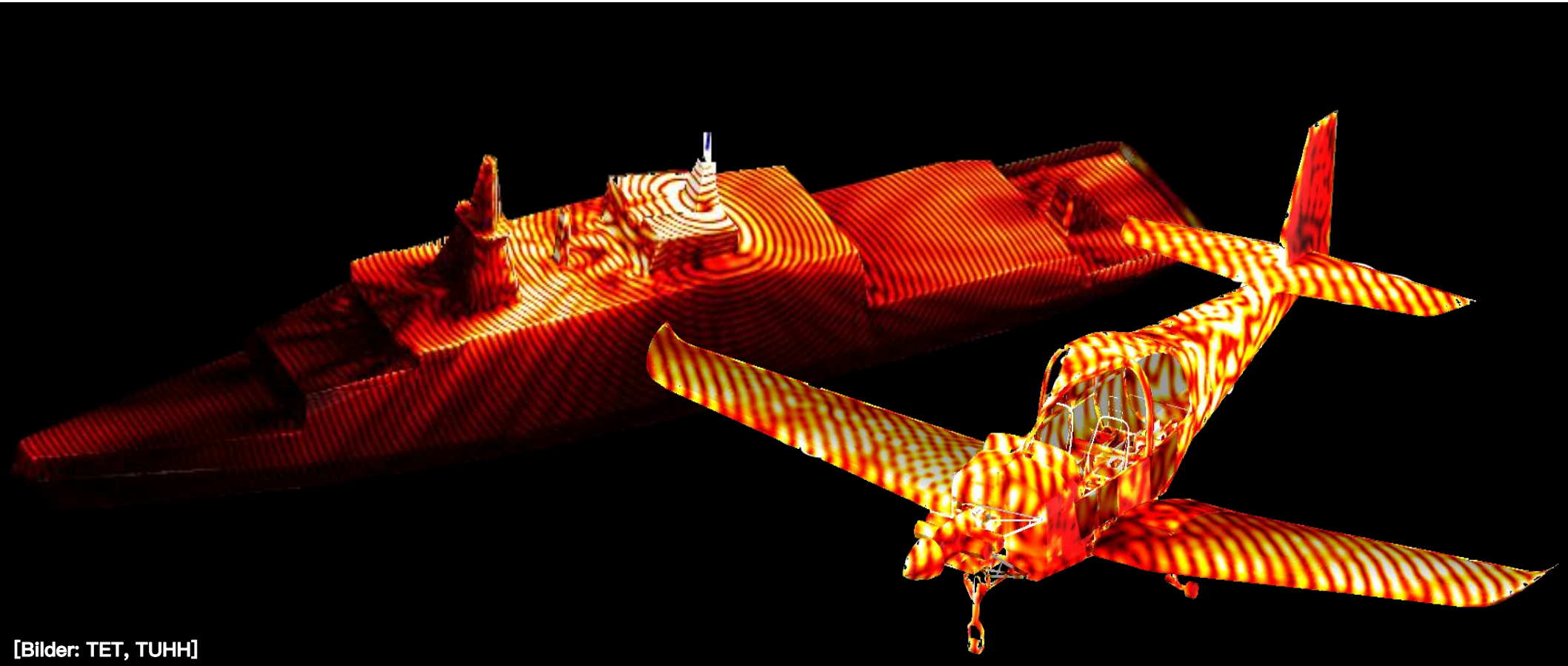
Course Overview, Winter Semester 2021/22



[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 (Theoretische Elektrotechnik).

Curriculum

Week	Topics	Chapter Script	Chapter Henke
1	Overview, repetition // Induction law	4.1	12.1
2	Continuation of induction law, principles of electrical machines	4.1	10.1, 10.2, 12.11
3	Transformation of fields, definition of inductance	4.1	10.1, 10.2, 12.11
4	Calculation of self and mutual inductances	4.2	10.1
5	Complex fields, introduction of field diffusion and skin effect	4.2	12.2, 12.4 –12.7
6	Skin effect calculation, concept of surface impedance	4.2	12.4, 12.5, 12.7
7	Power flow, induction heating, screens	4.3, 4.4	12.9, 13.2, 13.3
8	Flux displacement // elementary forms of dynamic fields, wave equation and their fundamental solutions	5.1, 5.2	14.1, 16.1
9	Wave number, wave impedance, power and attenuation	5.3	14.2
10	Plane waves in three dimensions, superposition and polarization of plane waves, visualization (**MATLAB**)	5.3	14.2
11	Reflection and refraction of plane waves, special case total reflection	5.3	14.4
12	Reflection on conductors, theory of waveguides, TEM waveguides	5.4	14.5
13	Waveguide modes, incl. calcalulation (MATLAB), resonators	5.4	14.5
14	Hertzian dipole, simple antennas, antenna parameters	5.5	16.2-16.5
14	Exam preparation		

The lecture and exercise will be given in presence at the University in this winter semester 2021-2022.

Goals of this Course

Students learn to explain fundamental formulas, relations, and methods related to the theory of time-dependent electromagnetic fields. They can assess the principal behavior and characteristics of quasistationary and fully dynamic 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-dependent electromagnetic fields and are able to explicate these.

Specifically students learn to apply a variety of procedures in order to solve the diffusion and the wave equation for general time-dependent field problems. They can assess the principal effects of given time-dependent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the characterization of fully dynamic fields (wave impedance, skin depth, Poynting-vector, radiation resistance, etc.) from given fields and interpret them with regard to 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:

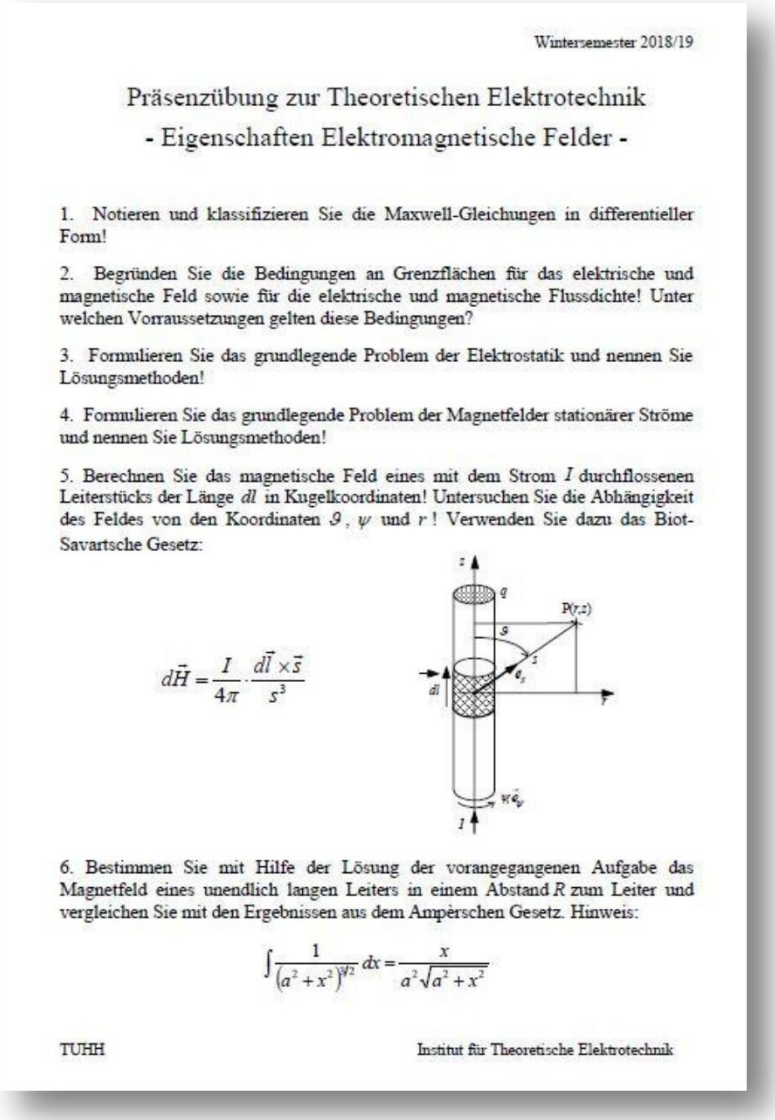
https://www.tuhh.de/rzt/software/numerik/matlab.html

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.



Wintersemester 2018/19

Präsenzübung zur Theoretischen Elektrotechnik

- Eigenschaften Elektromagnetische Felder -

1. Notieren und klassifizieren Sie die Maxwell-Gleichungen in differentieller Form!

2. Begründen Sie die Bedingungen an Grenzflächen für das elektrische und magnetische Feld sowie für die elektrische und magnetische Flussdichte! Unter welchen Vorraussetzungen gelten diese Bedingungen?

3. Formulieren Sie das grundlegende Problem der Elektrostatik und nennen Sie Lösungsmethoden!

4. Formulieren Sie das grundlegende Problem der Magnetfelder stationärer Ströme und nennen Sie Lösungsmethoden!

5. Berechnen Sie das magnetische Feld eines mit dem Strom I durchflossenen Leiterstücks der Länge dl in Kugelkoordinaten! Untersuchen Sie die Abhängigkeit des Feldes von den Koordinaten ϑ, ψ und r! Verwenden Sie dazu das Biot-Savartsche Gesetz:

$$d\vec{H} = \frac{I}{4\pi} \cdot \frac{d\vec{l} \times \vec{s}}{s^3}$$

6. Bestimmen Sie mit Hilfe der Lösung der vorangegangenen Aufgabe das Magnetfeld eines unendlich langen Leiters in einem Abstand R zum Leiter und vergleichen Sie mit den Ergebnissen aus dem Ampèrschen Gesetz. Hinweis:

$$\int \frac{1}{(a^2+x^2)^{3/2}}\,dx = \frac{x}{a^2\sqrt{a^2+x^2}}$$

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Script

Students can get a free script from the Institute of Electromagnetic Theory.

Scripts are distributed at the beginning of the semester.

Alternatively, scripts can be obtained from the secretary's office of the institute. Please make an appointment with Ms. Pelin Usta:

pelin.usta@tuhh.de


TECHNISCHE UNIVERSITÄT
HAMBURG - HARBURG

Institut für
Theoretische Elektrotechnik

Skriptum

Theoretische Elektrotechnik I + II

– 2017 –

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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)
- M. Filtz, H. Henke, "**Übungsbuch Elektromagnetische Felder**", Springer (E-Book TUHH)
- G. Lehner, "**Elektromagnetische Feldtheorie für Ingenieure und Physiker**", Springer, 2010 (E-Book, TUHH)

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.