

Preliminary meeting about Proseminar on Linear Algebra

Winter Semester 2020/2021

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Today's agenda

- 1 Overview
 - Aim and structure
 - Requirements
 - Timeline and Final Grade
- 2 Preparing your presentation
 - Assistance in the preparation
 - Seminar Topics
 - Discussion and assignment
- 3 Next appointments

Description

- Why?

Develop in more detail topics in Linear Algebra
(results introduced in “**Lineare Algebra II**” and beyond).

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- What?

Each participant delivers a **presentation**, providing a **review** of the results from the literature and illustrating them with **examples and applications**.

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- What?

Each participant delivers a **presentation**, providing a **review** of the results from the literature and illustrating them with **examples and applications**.

- How?

Every student chooses a topic and produces:

- oral presentation and the support needed to deliver it
- short abstract
- handout (max 10 pages).

Requirements and Validation

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- **Prerequisites:**
 - Linear Algebra I
 - Linear Algebra II

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- German
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- **Validation:**

- BA Proseminar (3 ECTS)
- Fachseminar (B.Ed., M.Ed. – 5 ECTS)

Time and Place

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- When?

Every Wednesday 13:30–15:00h starting on November 4th

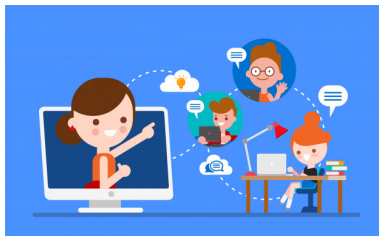
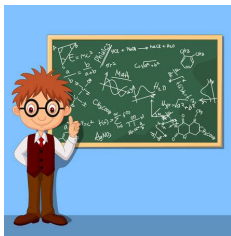
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- Where?

There is a chance that this seminar cycle might be held in video conference on **Cisco Webex Meetings** rather than **in presence at the university**.



Deadlines and Final Grade

Your deadlines:

- **one week before your seminar by noon:** send us the title and abstract of your seminar
- **at the beginning of your talk:** send us your handout
- **your seminar duration:** 1 hour 15 minutes (plus 15 additional minutes for questions).
- **one week after receiving the feedback on your handout:** send us the final version of your handout

Your final grade includes the evaluation of:

- your presentation
- your handout
- your active participation to the other's seminars

Your presentation

In case the seminar will be given in presence at the university:

- presenting at the blackboard
- projecting a visual support (e.g. slides)

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- sharing your notes on a tablet
- sharing your slides

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Do you need help?

Personal tutorial and Templates

We offer you a **Personal Tutorial** on the week before your talk to assist you in the preparation of your talk, abstract and handout.

Further personal tutorials can be arranged by appointment!

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- a sample LaTeX presentations

Possible Topics

We suggest six main topics:

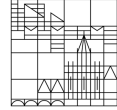
- 1 **Operators on inner product spaces**
- 2 **Applications of the spectral theorem**
- 3 **Bilinear forms**
- 4 **Applications of Zorn's Lemma**
- 5 **Applications of Jordan forms**
- 6 **Linear algebraic problems in mathematical physics**

Possible Topics

We suggest six main topics:

- 1 **Operators on inner product spaces**
- 2 **Applications of the spectral theorem**
- 3 **Bilinear forms**
- 4 **Applications of Zorn's Lemma**
- 5 **Applications of Jordan forms**
- 6 **Linear algebraic problems in mathematical physics**

Let us look at more detailed subtopics of those six!



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List of possible topics

This is just a list of possible topics where you can find some ideas and references for preparing your seminars. Please, feel free to search for other sources and/or to propose to us a completely different topic in linear algebra on which you would like to build your own seminar.

1. Operators on inner product spaces

- (a) **Forms on inner product spaces and their representations**
(See e.g. [4, Section 9.2, pp. 320–324].)
- (b) **Nonnegative and positive forms on inner product spaces**
(See e.g. [4, Section 9.3, pp. 325–329].)
- (c) **Relation between positive operators, positive forms and positive matrices**
(See e.g. [4, Section 9.3, pp. 329–331].)
- (d) **Forms and projections of vectors spaces**
(See e.g. [4, Section 9.4, pp. 332–334].)

2. Applications of the spectral theorem

- (a) **Functions of diagonalizable normal operators**
(See e.g. [4, Section 9.5, pp. 337–340].)
- (b) **Applications involving nonnegative operators**
(See e.g. [4, Section 9.5, pp. 340–343].)
- (c) **Simultaneous diagonalization of families of normal operators**
(See e.g. [4, Section 9.5, pp. 343–347].)
- (d) **Spectral theorem and primary decomposition**
(See e.g. [4, Section 9.6, pp. 349–352].)
- (e) **Properties of normal operators on real vector spaces**
(See e.g. [4, Section 9.6, pp. 352–354].)
- (f) **Unitarily equivalence of normal operators**
(See e.g. [4, Section 9.6, pp. 354–358].)

3. Bilinear forms

- (a) **Bilinear forms on finite-dimensional vector spaces**
(See e.g. [4, Section 10.1, pp. 360–366].)
- (b) **Symmetric bilinear forms and their diagonalization**
(See e.g. [4, Section 10.2, pp. 367–372].)
- (c) **Skew-symmetric bilinear forms**
(See e.g. [4, Section 10.3, pp. 375–379].)
- (d) **Group preserving bilinear forms**
(See e.g. [4, Section 10.3, pp. 379–383].)

4. Applications of Zorn's Lemma

- (a) **Zorn's Lemma in the proof that any vector space has a basis**
(See e.g. [1, Section 14.2].)
- (b) **Zorn's Lemma in the Hahn–Banach Theorem for linear functionals or in the proof of the existence of maximal ideals**
(See e.g. [1, Section 14, pp. 235–247].)
- (c) **Tukey's Lemma: an equivalent version of Zorn's Lemma**
(See e.g. [1, p. 245].)

5. Applications of Jordan forms

- (a) **Jordan form of a nilpotent matrix**
(See e.g. [8, Section 4.2], [3, Section 6.5], [2, Section 57].)
- (b) **Applications of Jordan forms to systems of linear ordinary differential equations**
(See e.g. [6, pp. 39–50].)

6. Linear algebraic problems in mathematical physics

Topics connecting linear algebra and mathematical physics can be found for example in [7]. In particular, three mathematical problems appearing in quantum mechanical models are sketched in [7, Volume I, Chapter VIII, Section 11] and deal with:

- (a) **self-adjoint extensions of symmetric operators**
(See e.g. [7, Volume II, Chapter X, Section 1].)
- (b) **spectral analysis**
(See e.g. [7, Volume IV, Chapter XIII].)
- (c) **scattering theory**
(See e.g. [7, Volume III, Chapter XI].)

7. Further references

More interesting topics can be found in [2], [5], [3, Chapter VI].

References

- [1] M. Carl, *Wie kommt man darauf?*, Springer Spektrum, Wiesbaden, 2017.
- [2] P. R. Halmos, *Finite-dimensional vector spaces*. Reprinting of the 1958 second edition. Undergraduate Texts in Mathematics. Springer, New York, 1974.
- [3] I. N. Herstein, *Topics in Algebra* (2nd ed.), John Wiley & Sons, 1975.
- [4] K. Hoffman, R. Kunze, *Linear Algebra*, Prentice-Hall, Englewood Cliffs, N.J., 1971.
- [5] F. Lorenz, *Lineare Algebra*, vol. I and II, Spektrum Akademischer Verlag, 2008.
- [6] L. Perko, *Differential equations and dynamical systems* (3rd ed.), Texts in Applied Mathematics 7, Springer, New York, 2001.
- [7] M. Reed, B. Simon, *Functional analysis* (2nd ed.), Methods of modern mathematical physics 1, Academic Press, San Diego, 1980.
- [8] H. Shapiro, *Linear Algebra and Matrices: Topics for a Second Course*, American Mathematical Society, Providence, R.I., 2015.

Assignment of Topics

- Questions?
- Further topic suggestions
- Round of preferences
- Assignment of Topics

Next appointments

- **Date Preferences:**
to be communicated to us before August 15th!

Next appointments

- **Date Preferences:**
to be communicated to us before August 15th!
- **Preliminary schedule:**
September 15th.

Next appointments

- **Date Preferences:**
to be communicated to us before August 15th!
- **Preliminary schedule:**
September 15th.
- **Final schedule:**
October 1st.

Next appointments

- **Date Preferences:**
to be communicated to us before August 15th!
- **Preliminary schedule:**
September 15th.
- **Final schedule:**
October 1st.
- **Any questions?**
Contact us via e-mail if you have questions of any kind:
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sebastian.krapp@uni-konstanz.de

*Thank you very much for your interest
and participation!*