VEKTORANALYS

HT 2021

CELTE / CENMI

ED1110 Vektoranalys 4.5 hp

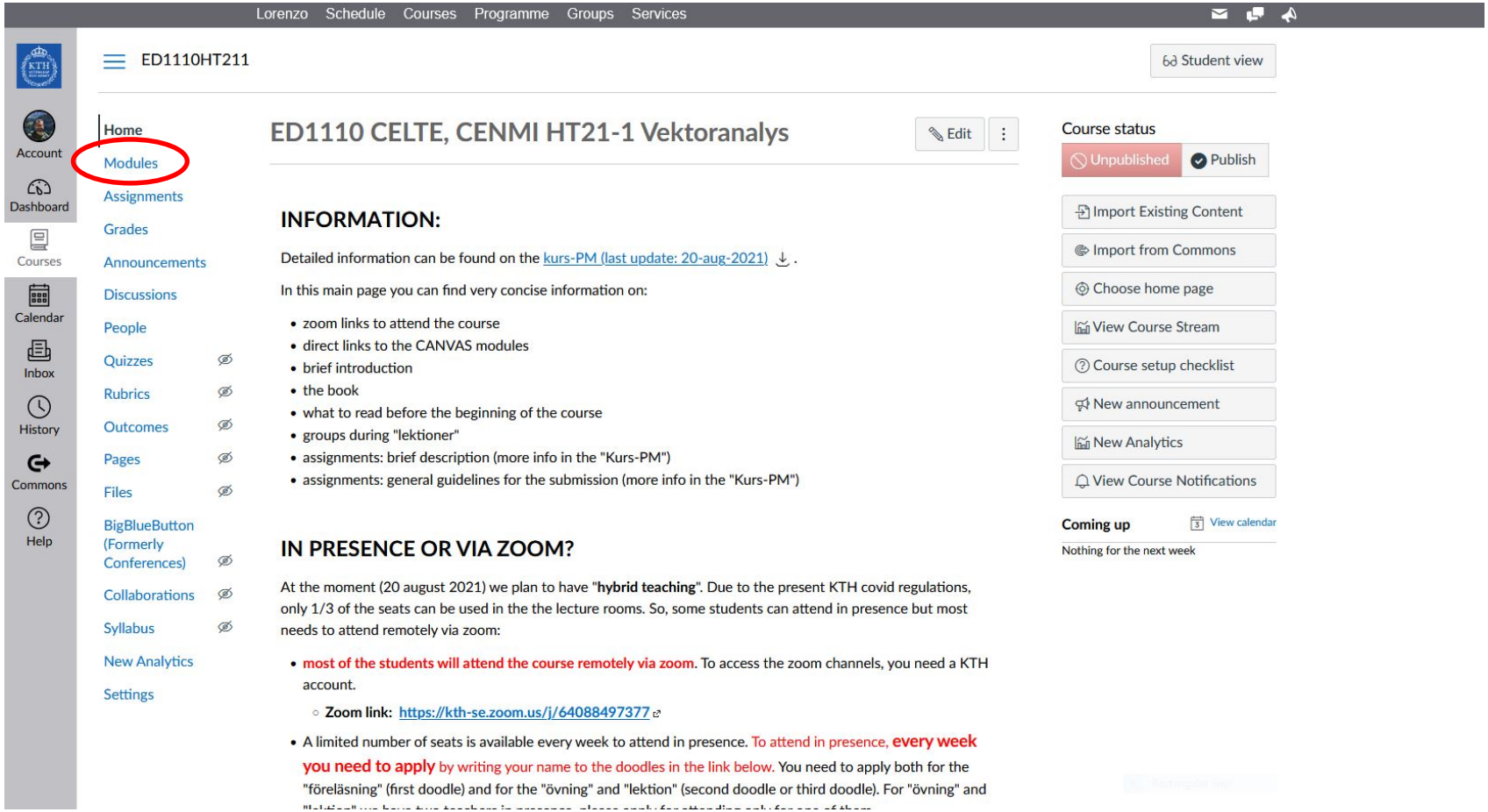
version: 28-aug-2021

1. THE COURSE WEBSITE: CANVAS

Address: *https://canvas.kth.se/courses/26752*

Information on the website:

- the kurs-PM (under “modules”)
- the slides of each lesson (under “modules”)
- earlier exams with solution (under “modules”)
- some solved exercises (under “modules”)



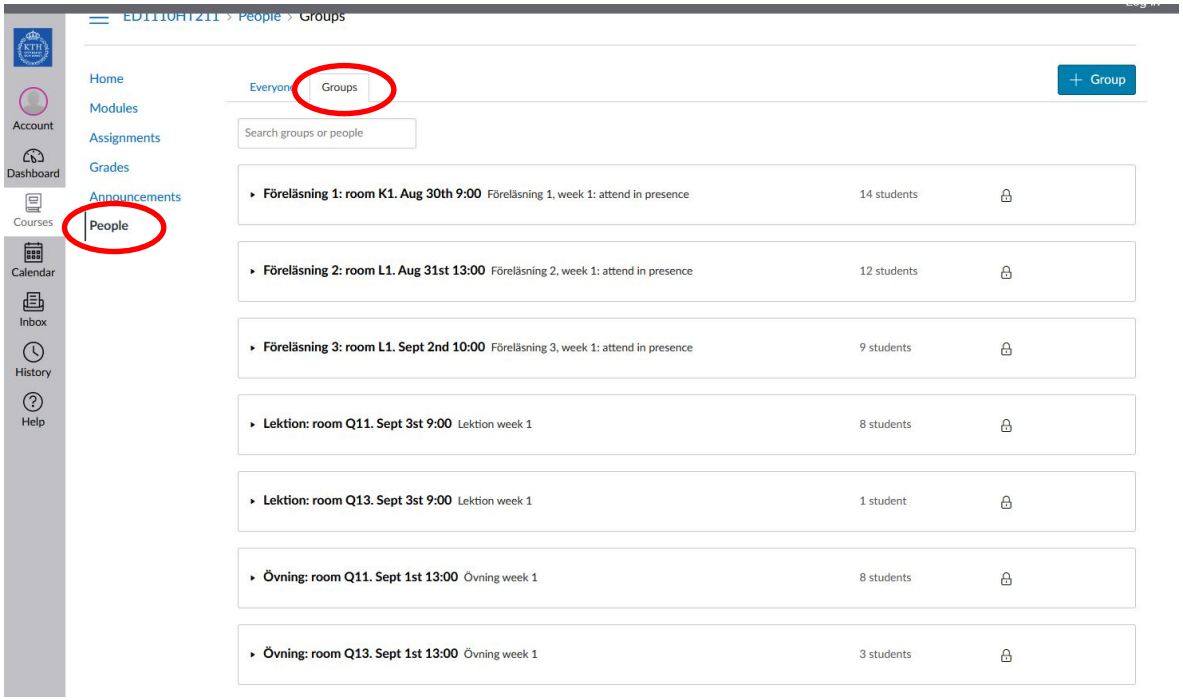
2. TEACHERS

Lorenzo Frassinetti	*e-mail: lorenzo.frassinetti@ee.kth.se*	
Erik Saad	*e-mail: esaad@kth.se*	*in presence*
Björn Ljungberg	*e-mail: bjoljung@kth.se*	*in presence*
Hampus Nyström	*e-mail: hampusny@kth.se*	*via zoom*
Laura Dittrich	*e-mail: lauradi@kth.se*	

In presence or via zoom?

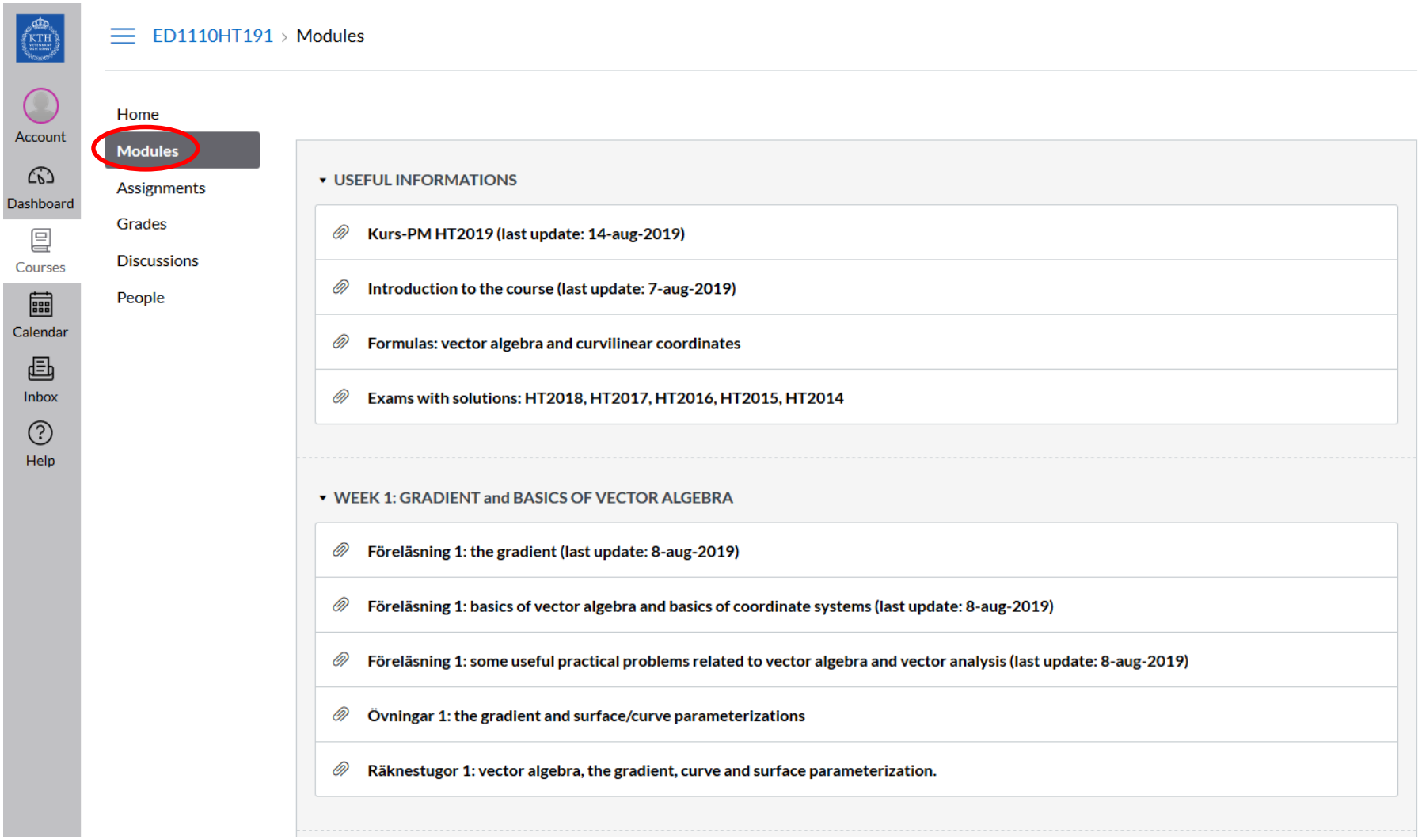
To attend in presence:

- Go to the canvas page of the course: https://canvas.kth.se/courses/26752
- Go in ”people” and select ”groups” (you need to be a ”registered student” to access ”people”)
- Apply every week and for every class you want to attend in presence



3. THE KURS-PM and other material

All the materials (slides of “föreläsning”, exercises, old exams) is on CANVAS:
https://canvas.kth.se/courses/26752/modules



4. THE BOOK

Title: Vektoranalys

Authors: L. Frassinetti, J. Scheffel

Editor: Liber

ISBN: 978-91-47-12617-0

Homepage: https://www.liber.se/serie/vektoranalys-28150

On the homepage you can download useful files:

- **Errata** (list of typos and minor errors in the book). Please, look at it carefully.
  https://www.liber.se/plus/E471261701.pdf
- **Hints** to solve the exercises of the book.
  https://www.liber.se/plus/E471261702.pdf
- **Full solutions** to the exercises of the book.
  https://www.liber.se/plus/E471261703.pdf
- **Appendix**: practical applications of the basic concepts.
  https://www.liber.se/plus/E471261704.pdf

KURSNÄMD

- Please, nominate three class “spokespersons”.
- There is an important requirement:

  At least one member needs to be a woman and one member a man:

  “KTH Equal opportunities policy: Both sexes are given the opportunity of collaborating on equal conditions. Women and men must have equal rights, obligations and opportunities at KTH.”

- Role of the “kursnämd”
  1. They will communicate suggestions/comments to the teacher in order to improve the course.
  2. In case of any problem, if you do not feel comfortable to contact directly the teachers, please contact the kursnämd. They will report to the problem to the teacher.

- Meetings with the “kursnämd”
  1. The teacher will meet the kursnämd twice: week 36 and week 38
  2. Likely, the meetings will be via zoom

CONTENT OF THE COURSE

Vecka 1

- Grundläggande vektoralgebra (Kapitel 1)
- Derivering och integration av vektorvärda funktioner i kartesiska, cylindriska och sfäriska koordinatsystem (Kapitel 2, 3)
- Gradienten och riktningsderivatan (Kapitel 4)
- Potentialen (Kapitel 5)

Vecka 2

- Linjeintegraler (Kapitel 6)
- Ytintegraler (Kapitel 7)

Vecka 3

- Divergensen och Gauss' sats (Kapitel 8)
- Rotationen och Stokes' satser (Kapitel 9)

Vecka 4

- Kroklinjiga koordinatsystem (Kapitel 10)

Vecka 5

- Nablaoperatorn och nablaräkning (Kapitel 11, 14)
- Indexräkning (Kapitel 12)
- Integralsatser (Kapitel 15)

Vecka 6

- Viktiga vektorfält och integration av dessa (Kapitel 16)
- Laplaces och Poissons ekvationer (Kapitel 17)

Vi kommer inte att läsa Kapitel 13 och Sektion 17.4

STRUCTURE OF THE COURSE

Each week is divide into three parts:

1. Föreläsningar (Lorenzo Frassinetti)

2. Övningar (Erik Saad, Björn Ljungberg, Hampus Nyström)
   in presence *via zoom*

3. Lektion (Erik Saad, Björn Ljungberg, Hampus Nyström)
   in presence *via zoom*

Föreläsningar (between 4h and 7h per week)

- Each week presents two main topics.
- Each topic starts with a "målproblem":
  - At the beginning of the lecture, the "målproblem" is introduced.
  - During the main part of the lecture, the mathematical tools to solve the "målproblem" are presented
  - At the end of the lecture, the "målproblem" is solved using these new mathematical tools.

Home assignment: 5 exercises (apart week 1, which has 10 exercises).

- The home assignment will give points to pass the exams. It is NOT compulsory.
- You can discuss the solution with other student, but remember:
  - plagiarism is not allowed
  - if two or more students will have solutions too similar and we suspect plagiarism, we might report to KTH. So:
    - do not copy from other students
    - do not copy from the web
    - do not copy from any book.
  - write your solutions alone, by yourself!

- Often, the last exercise is on vector algebra.
- The home assignment must be handed in via CANVAS, typically **on the following Monday by 8am**.
- *More info later in this presentation.*

Övningar (typically 2h per week)

The aim is to:

- give practical applications of vector analysis
- train you to go from problem formulation to the final solution

PART 1:

The teacher solve some problems related to the topics discussed during the lecture.

- We start from a simple problem and at the end of the lesson we solve something more advanced.

PART 2: Last 30min of the second hour

- 25minuts for: **GROUP ASSIGNMENT**
  - you will be divided in small groups composed of 2 or 3 people in zoom breakout rooms (or in the class).
  - You have to discuss the solution of the assignment within your group.
  - You can use your notes and my slides. Not the book nor the web.
  - For full points, all the logic steps of the solution must correct.
  - You must keep the camera on and be visible till the end of the class (even after you have submitted).
- Each student has to write his own solution and submit it via CANVAS.
- The last 5min are for uploading the solution on CANVAS
  - We accept only pdf files.
  - Also the students attending in presence must submit via CANVAS
- The assignment is NOT compulsory but can give points for the exam.

Lektion (typically 2h per week)

PART 1:

- You will be able to download from CANVAS some problems and then you solve them by yourself.
- The teacher will be available for any question and clarification.

PART 2: Last 30min of the second hour

- 25minuts for: **INDIVIDUAL ASSIGNMENT**
  - You will solve individually a problem.
  - You can use your notes and my slides. Not the book nor the web.
  - To pass the assignment, all logic steps of the solution must be correct.
  - You must keep the camera on and be visible till the end of the "lektion" (even after you have submitted).
  - We might also ask you to switch on the microphone.

  If these rules are not followed, we will not grade your assignment.
- The last 5min are for uploading the solution on CANVAS
  - We accept only pdf files.
  - Also the students attending in presence must submit via CANVAS

- The assignment is NOT compulsory but can give points for the exam.

LÄRANDEMÅL (ILOs)

The course has 6 Intended Learning Outcomes (ILOs or ”lärandemål”). Each week is devoted to a specific ILO.

1. *tillämpa vektoralgebra och använda gradienten av skalärfält för att lösa elementära problem inom fysiken*
2. *utföra linje-, yt- och volymsintegration samt derivering av skalärfält och vektorfält*
3. *fysikaliskt tolka divergensen och rotationen och tillämpa dessa operatorer för att utföra yt- och linjeintegration med hjälp av Gauss’ och Stokes’ satser*
4. *identifiera det mesta lämpliga koordinatsystemet för ett givet problem och tillämpa gradienten, divergensen och rotationen i det utvalda koordinatsystemet*
5. *använda nablaräkning och indexräkning för att förenkla och utföra vektoranalytiska beräkningar*
6. *lösa Poissons ekvation med lämpliga randvillkor för problem med cylindriska och sfäriska symmetrier.*

To pass the course, all the ILOs must be fulfilled.
We will test 1 ILO per week.

CONTINUAL EXAMINATION (not compulsory)

The **continual examination** is the set of:

(a) **home assignments**

- they must be handed in at 8am on the Monday of the following week via CANVAS.
  Example: the home assignment of this week must be handed in at 8am on the Monday of next week.
- Grade of each assignment: maximum 1.0 points.
- The solutions must be:
  - Individual: you can discuss with other students, but you have to write your own solutions. **Plagiarism is not allowed**. Identical solutions from two students will not be accepted.
  - precise and exact: the correct logic is not sufficient for full points
  - well written and clear to read: if we cannot read the assignment → 0 points
  - use the standard and correct mathematical notation → each error on vector algebra notation is -0.1 points

(b) **group assignment** at the end of the "övning"

- Duration: 25min (+5min for submission). Three students per group (groups are made by the teacher)
- Grade of each assignment: maximum 0.25points.
- You can use your notes and my slides. You cannot use the book nor the web.

(c) **individual assignment** at the end of the "lektion"

- Duration: 25min (+5min for submission).
- Grade of each assignment: Pass / Fail.
- Criteria for "Pass": all the logic steps of the solution must be correct
- You can use your notes and my slides. You cannot use the book not the web.

We will have an home assignment, a group assignment and an individual assignment, each week. They will be used to test the ILO of the week.

An ILO is considered to be fulfilled if

- you achieve **at least 0.75 points** when adding together the **home assignment and the group assignment**
- **and** you **pass the individual assignment**.

If you fulfill all the six ILOs during the continual examination, you will get the grade E and you will not need to attend the tenta.
Each fulfilled ILO will give 1.5 points for the tenta (so, a maximum of 1.5x6=9points if you fulfil all the ILOs)
An ILO that that is not fulfilled will give 0 points for the tenta.

Submission of assignments: general comments

- Submission is via CANVAS
- We accept only:
  - **PDF files** (for example, you can use the ScanPro app. See kurs-PM for details)
  - **One single file per assignment**
- Write your name on the top of the paper. We disregard assignments with no name.
- All the students, also those attending in presence, have to submitt the assignments via CANVAS.
- It is your responsibility to verify that:
  - the pdf file with your solution is clear and legible
  - That your handwriting is clear and legible.
  - **If the teacher can not read your solution, the assignment will not be graded.**

- use clear logic steps.
- highlight the solution (for example with a double line).
- simplify mathematical expressions (for example: 8/2 wtite 4, $9^{1/2}$ write 3)

Submission of assignments

- **Submission** is with a **pdf file** via CANAS: https://canvas.kth.se/courses/26752/assignments .
  - Select the assignment, then select ”submitt assignment”
- **Home assignments**:
  - You have solve it individually. Plagiarism is not allowed.
  - You have approximately 1 week. The deadline is 8am on Monday of the following week
- **Group assignments**:
  - You can discuss with the students in your zoom breakout room or group.
  - But you have to write and submitt your own solution.
  - You **can use your notes and the slides of course**
  - You **may not use any book nor internet**
  - You must keep **camera on (otherwise your assignement will not be graded)**.
  - We might ask you to keep the microphone on.
  - The assignement starts 30min before the end of ”övning”.
  - You have **25min** to solve it and 5min to submitt it.
  - CANVAS is open for submission till 10min after ”övning”
- **Individual assignments**:
  - You may not ask help to anyone.
  - You **can use your notes and the slides of course**
  - You **may not use any book nor internet**
  - You must keep **camera on (otherwise your assignement will not be graded)**.
  - We might ask you to keep the microphone on.
  - The sssignement starts 30min before the end of ”lektion”.
  - You have **25min** to solve it and 5min to submitt it.
  - CANVAS is open for submission till 10min after ”lektion”

TENTA

Do you need to attend the "tenta"?

You need to attend the "tenta" if:

- you have not attended the continual examination
- you have not fulfilled all the ILOs during the continual examination
- you have fulfilled all the ILOs but you want a grade higher than E

How is the tenta structured?

The tenta has 8 problems. **Each problem can give up to 3 points**.

The tenta will contain two types of problems

- 6 basic problems, each problem devoted to a specific ILO. Maximum 3 points per problem.
- 2 advanced problems, for those who want grade B or grade A. Maximum 3 points per problem.

At least one problem will be theoretical where you have to present the proof one of the theorems done during lectures.

If you have passed only some ILOs during the continual examination, which problems should you solve?

To reach E, you need to

- solve the **problems corresponding to the ILOs that you have not yet fulfilled** in the continual examination **and**
- Reach at least **1.5 points per ILO**.
- **Example:**
  - Student "Zlatan Ibrahimovic" has fulfilled ILO 1, ILO 3, ILO 4 and ILO 5 during the continual examination. But he has not fulfilled yet ILO 2 and ILO 6.
  - Then, to reach E, "Zlatan" needs to attend the tenta and:
    - solve at least problem 2 and problem 6.
    - reach at least 1.5 points in problem 2 and 1.5 points in problem 6.

After all the six ILOs have been fulfilled (either from the continual examination or from the tenta), you will have **1.5 points per ILO**. So, in total 9 points.

TENTA

What should you do to get a grade higher than E?

If you want an higher grade, you need to attend the "tenta".
The requirememnt for higher grades are the following:

- **Grade D**: same requirements **as grade E** and at least a total of **12 points**
- **Grade C:** same requirements **as grade E** and at least a total of **15 points**
- **Grade B**: same requirements **as grade E** and at least a total of **18 points** (with at least **2 points from problem 7 or problem 8**, which are the advanced problems)
- **Grade A**: same requirements **as grade E** and at least a total of **21 points** (with at least **2 points from problem 7 and 2 points from problem 8**, which are the advanced problems)

What happens if you do not fulfil all the ILOs even after the tenta?

If you do not fulfil all the ILOs even after the tenta, there are two possibilities:

- if you have **fulfilled 4 ILOs or less**, you need to attend the **omtenta**
- if you have **fulfilled at least 5 ILOs**, the grade is **FX**

Omtenta

- Only the ILOs fulfilled during the continual examination will still be valid.
- The ILOs fulfilled at the tenta will NOT be valid anymore.

How to complete the course if you got FX?

If you got FX you need to:

- contact the teacher (L. Frassinetti)
- the teacher will send you a problem for each of the not fulfilled ILOs
- within 6 weeks from the end of the course you need to solve the problems and send them to me
- if you get at least 2.5points over 3 points per each problem, your grade will be updated.

Plussning

There is only one way to improve the grade you have received at the tenta:

- attend the omtenta in December. However, note that the ILOs fulfilled at the tenta will not be valid anymore. Only the ILOs fulfilled in the continual examination will be valid.

TENTAMEN

v 43	Friday 2021-10-22		
	8:00-12:00	Tentamen	ED1110
v 51	Wednesday 2021-12-22		
	14:00-18:00	Omtenta	ED1110

- **Duration 4h**
- **Via “zoom närvaro”**
- Do not forget to apply for the tenta (same rule of any KTH course)
- Funka students: please, contact funka for details
- More details will be uploaded on CANVAS 1-2 weeks before the tenta.

GRADES on CANVAS

- Results of the continual examination will be uploaded on CANVAS:

  https://canvas.kth.se/courses/26752/grades

- It is rather complicated to transfer the grades to CANVAS:
  - Please, be patient
  - check weekly that we have stored the correct grades (if not send us an e-mail)

Name	Due	Score	Out of
Individual assignment 1		1 (P)	1
Group assignment 1		0.1	0.25
Home assignment 1	2 Sep by 15:00	0.7	1
Intended Learning Outcome 1		1.5 (P)	1.5
Individual assignment 2		0 (F)	1
Group assignment 2		0.25	0.25
Home assignment 2	9 Sep by 8:00	0.95	1
Intended Learning Outcome 2		0 (F)	1.5

Week 1	29.33%	1.10 / 3.75
Week 2	72%	2.70 / 3.75
Week 3	56%	2.10 / 3.75
Week 4	66.67%	2.50 / 3.75
Week 5	60%	2.25 / 3.75
Week 6	94.67%	3.55 / 3.75
Tenta	N/A	0.00 / 0.00
Total	63.11%	14.20 / 22.50

GRADES on CANVAS

- Results of the continual examination will be uploaded on CANVAS:

  https://canvas.kth.se/courses/26752/grades

- It is rather complicated to transfer the grades to CANVAS:
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Name	Due	Score	Out of
Individual assignment 1		1 (P)	1
Group assignment 1		0.1	0.25
Home assignment 1	2 Sep by 15:00	0.7	1
Intended Learning Outcome 1		1.5 (P)	1.5
Individual assignment 2		0 (F)	1
Group assignment 2		0.25	0.25
Home assignment 2	9 Sep by 8:00	0.95	1
Intended Learning Outcome 2		0 (F)	1.5

Week 1	29.33%	1.10 / 3.75
Week 2	72%	2.70 / 3.75
Week 3	56%	2.10 / 3.75
Week 4	66.67%	2.50 / 3.75
Week 5	60%	2.25 / 3.75
Week 6	94.67%	3.55 / 3.75
Tenta	N/A	0.00 / 0.00
Total	63.11%	14.20 / 22.50

Neglect this part:
It is created automatically by CANVAS asnd I cannot remove it

WHY VECTOR ANALYSIS?

VECTOR ALGEBRA — sum, subtraction, scalar product, cross product } of vectors

VECTOR ANALYSIS — derivation and integration } of combinations of scalars and vectors

Essential tool in many areas of engineering and physics

WHY VECTOR ANALYSIS?

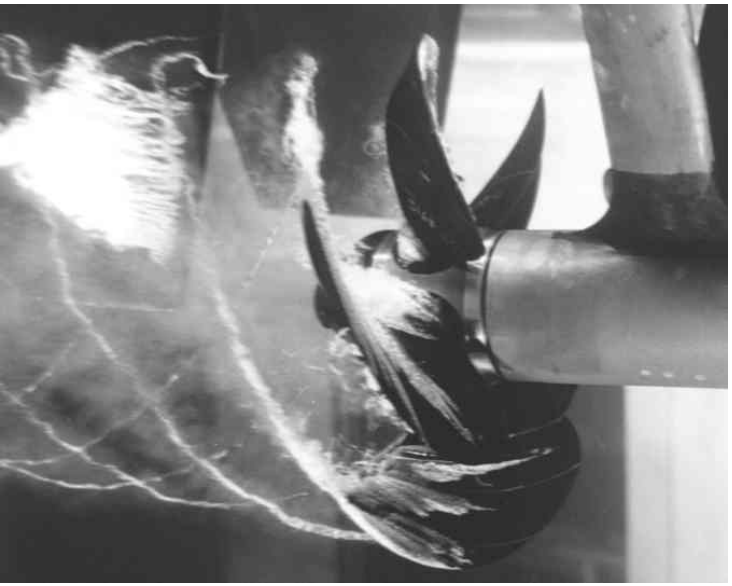
HYDRODYNAMIC: Navier-Stokes equations

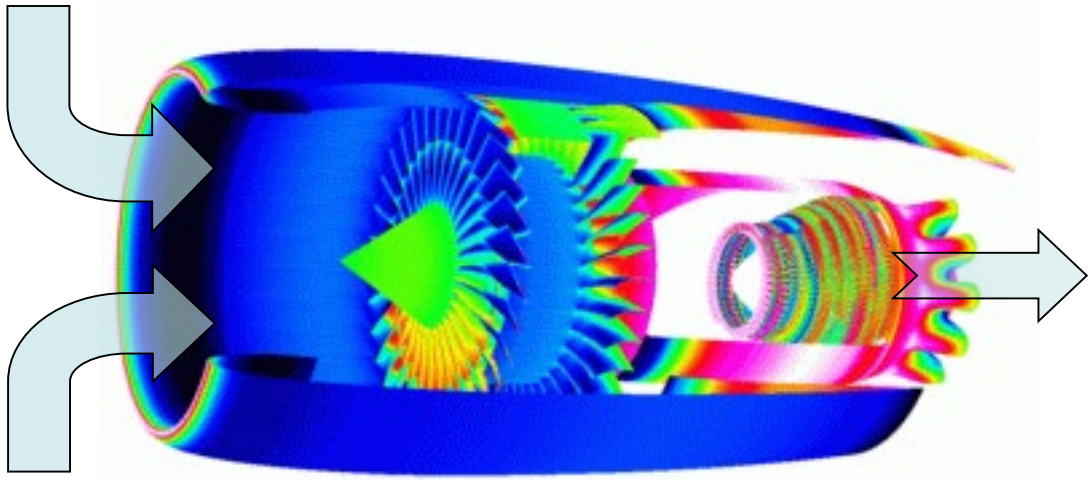
(meteorology, aero-space engineering, turbulence…)

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \rho \overline{v} = 0$$

$$\nabla \cdot \overline{v} = 0$$

$$\rho\left(\frac{\partial \overline{v}}{\partial t} + \overline{v} \cdot \nabla \overline{v}\right) = -\nabla p + \mu \nabla^2 \overline{v} + \overline{f}$$





WHY VECTOR ANALYSIS?

THEORETICAL ELECTRONICS: Maxwell equations

(electronic engineering, telecommunications…)

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} - \vec{M}$$

$$\nabla \times \vec{H} = -\frac{\partial \vec{D}}{\partial t} + \vec{J}$$

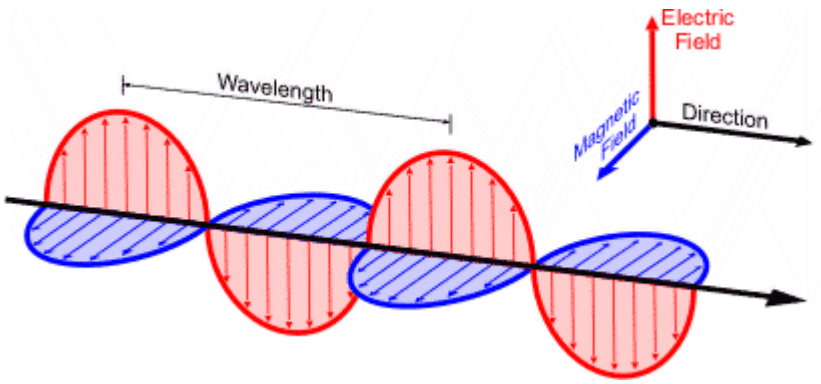
$$\nabla \cdot \vec{D} = \rho$$

$$\nabla \cdot \vec{B} = 0$$

Electromagnetic waves:

(electronic engineering, telecommunications…)

$$\nabla \times (\nabla \times \vec{E}) = -\mu_0 \varepsilon \frac{\partial^2 \vec{E}}{\partial t^2} - \mu_0 \frac{\partial \vec{j}}{\partial t}$$

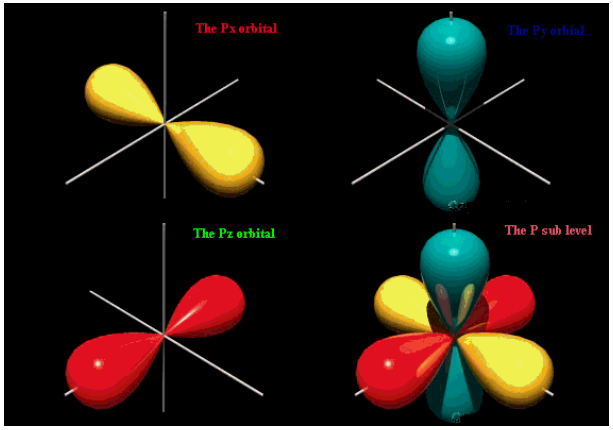


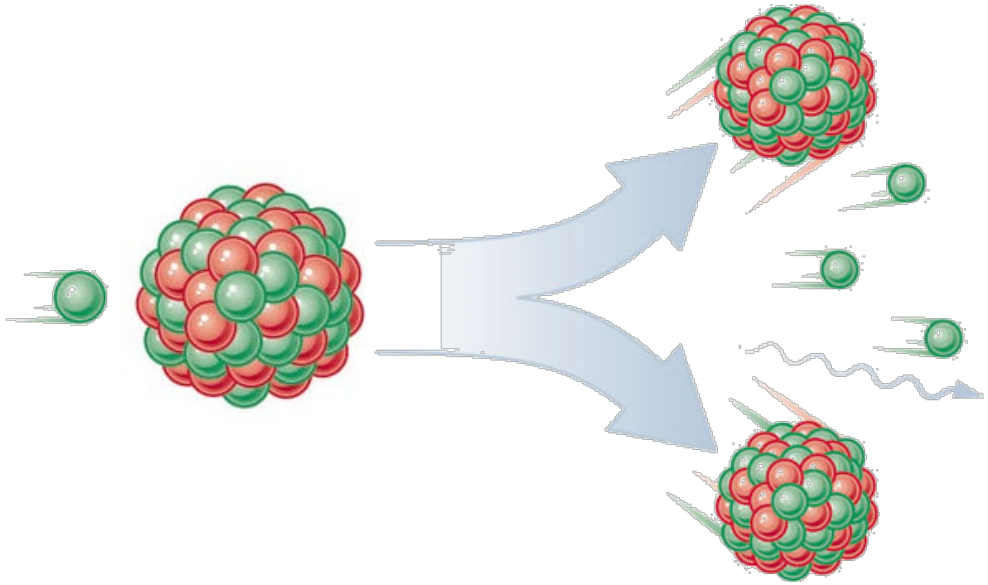
WHY VECTOR ANALYSIS?

MODERN PHYSICS: Schrödinger equation

(atom description, nuclear physics…)

$$i\hbar\frac{\partial}{\partial t}\psi = -\frac{\hbar^2}{2m}\nabla^2\psi + V\psi$$





WHY VECTOR ANALYSIS?

PLASMA PHYSICS: Magnetohydrodynamic equations

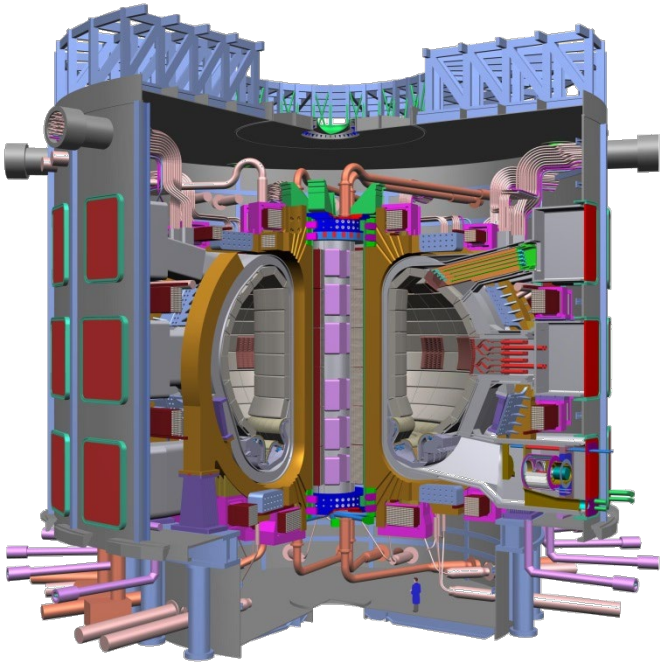
(dynamics of a electrically charged fluid "plasma": nuclear fusion, space physics…)

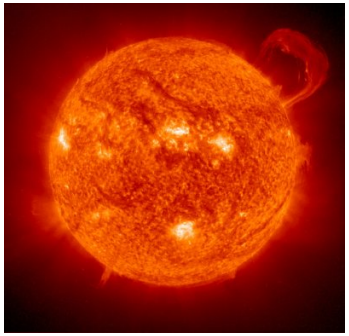
$$\rho\left[\frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v}\cdot\nabla)\,\boldsymbol{v}\right] = \frac{1}{\mu}(\nabla\times\boldsymbol{B})\times\boldsymbol{B} - \nabla p,$$

$$\frac{\partial \boldsymbol{B}}{\partial t} = \nabla\times(\boldsymbol{v}\times\boldsymbol{B}) + \eta\nabla^2\boldsymbol{B},$$

$$\frac{\partial \rho}{\partial t} + \nabla\cdot(\rho\boldsymbol{v}) = 0,$$

$$\frac{\partial p}{\partial t} + (\boldsymbol{v}\cdot\nabla)\,p = -\gamma p\nabla\cdot\boldsymbol{v},$$





WHY VECTOR ANALYSIS?

EI1220 | 10.5 CREDITS

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Course overview

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Schedule

General

Kursmaterial

Course plan etc

Course wiki

Electromagnetic Theory E

Selection

Välkomment till Teoretisk elektroteknik E (TET-E)

Kursen ges under hösten 2016. Undervisningen **startar 28:a September**, en kursplan kommer upp i vecka dess förinnan, vi börjar första veckan med Kap. 3.1-3.3 samt kap 3.5 i Cheng.

Vi kommer att använda mycket information från vektoranalys, linjär algebra och differential-ekvationer och integration. Mycket av den matte som ingår i ingenjörsutbildningen används i kursen. Det är en bra ide att repetera före, och fundera igenom Greens sats, stokes sats, vektorer i sfäriska (cylindriska) koordinater, samt integraler av uttryck som (x^2+y^2)^(-1/2) mm. Lite repetition finns bla i kapitlen 2 i Cheng's Field and Wave Electromagnetics.

Vi kommer att använda **Cheng's Field and Wave Electromagnetics**, som lärobok tillsammans med **Gunnar Peterssons "Teoretisk Elektroteknik"** studie-häfte. Studiehäftet finns till försäljning på STEX och vid behov trycker vi upp ytterligare exemplar. Äldre elever som redan har Peterssons studie-häfte kan gärna använda dem. Det nya häftet har enstaka fel rättade, men stämmer i övrigt med de tidigare versionerna.

Mvh/Lars

REPORT ABUSE

▸ Course home page (in Swedish)

Teachers

Lars Jonsson
Examiner, Course responsible, Teacher

CELTE

WHY VECTOR ANALYSIS?

CENMI/ELP

ELECTROMAGNETIC THEORY, INTRODUCTORY COURSE FOR ENERGY AND ENVIRONMENT
EI1225 | 6.0 CREDITS

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KTH / COURSE WEB / ELECTROMAGNETIC THEORY, INTRODUCTORY COURSE FOR ENERGY AND ENVIRONMENT

Electromagnetic Theory, Introductory Course for Energy and Environment

Selection

Välkomment till Teoretisk elektroteknik ME (TET-ME)

Kursen ges under hösten 2015. Undervisningen startar 21:a September.

Vi kommer att använda Cheng's Field and Wave Electromagnetics, tillsammans med Gunnar Peterssons studie-häfte.

Kursen samundervisas med EI1220, och kursmaterial, kurspm mm kommer att finns på sidan EI1220-sidan

OBS! Hjälpmedel till tentan och kontrollskrivningar: 1 A4 med egna handskrivna anteckningar, samt beta formelsamling. Kursen EI1225 löper parallellt med EI1220 fram till och med 2:a kontrollskrivningen. Mvh/Lars

REPORT ABUSE

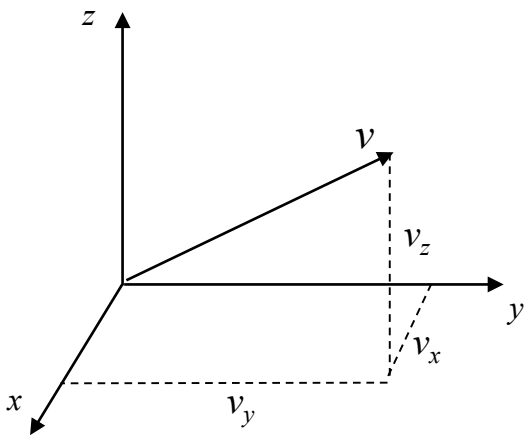
▸ Course home page (in Swedish)

Teachers

Lars Jonsson
Examiner, Course responsible, Teacher

VECTOR ALGEBRA

(A QUICK OVERVIEW)



$$\vec{v}=(v_x,v_y,v_z)$$

$$\boldsymbol{v}=(v_x,v_y,v_z)$$

$$\bar{v}=(v_x,v_y,v_z)$$

equivalent notations to identify a vector

always highlight that a variable is a vector!

Absolute value of a vector $\left|\bar{V}\right|=\sqrt{V_x^2+V_y^2+V_z^2}$

Sum $\bar{a}+\bar{b}=(a_x+b_x,a_y+b_y,a_z+b_z)$

Subtraction $\bar{a}-\bar{b}=\bar{a}+\left(-\bar{b}\right)=(a_x-b_x,a_y-b_y,a_z-b_z)$

Multiplication with a scalar c $c\bar{a}=(ca_x,ca_y,ca_z)$

Scalar product

$$\bar{a}\cdot\bar{b}=a_x\cdot b_x+a_y\cdot b_y+a_z\cdot b_z$$

$$\bar{a}\cdot\bar{b}=\left|\bar{a}\right|\left|\bar{b}\right|\cos\alpha$$

$$\bar{a}\cdot\bar{b}=0 \quad\Leftrightarrow\quad \bar{a}\perp\bar{b}$$

Basis vectors
in a Cartesian coordinate system:

$$\hat{e}_x=(1,0,0)$$

$$\hat{e}_y=(0,1,0)$$

$$\hat{e}_z=(0,0,1)$$

$$\Longrightarrow \bar{a}=a_x\hat{e}_x+a_y\hat{e}_y+a_z\hat{e}_z$$

Note that they have absolute value =1

poll 25

VECTOR ALGEBRA

(A QUICK OVERVIEW)

Cross product

$$\bar{a}\times\bar{b}=\begin{vmatrix}\hat{e}_x & \hat{e}_y & \hat{e}_z\\ a_x & a_y & a_z\\ b_x & b_y & b_z\end{vmatrix}$$

$$\left|\bar{a}\times\bar{b}\right|=\left|\bar{a}\right|\left|\bar{b}\right|\sin\alpha$$

$\bar{a}\times\bar{b}$ is a vector perpendicular to both $\bar{a}$ and $\bar{b}$

$$\bar{a}\times\bar{b}=-\bar{b}\times\bar{a}$$

$$\hat{e}_x\times\hat{e}_y=\hat{e}_z$$
$$\hat{e}_y\times\hat{e}_z=\hat{e}_x$$
$$\hat{e}_z\times\hat{e}_x=\hat{e}_y$$

VECTOR OR SCALAR?

(1)	$a\,\overline{v}$	vector
(2)	$\overline{v}\,\overline{a}$	wrong expression
(3)	$\overline{k}\cdot\overline{n}$	scalar
(4)	$c\times\overline{n}$	wrong expression
(5)	$b\cdot\overline{a}$	wrong expression
(6)	$\overline{a}\times\overline{n}$	vector

Which of these expressions is

a vector,
a scalar,
a wrong expression ?

Home assignments and final exam: -0.1 points each time you will write a wrong expression

Poll 4

VECTOR OR SCALAR?

(1) $\left(\left(c\,\bar{v}\right)\times\bar{b}\right)\cdot\bar{a}$ scalar

(2) $\left(\bar{v}\times\bar{a}\right)\bar{a}c$ wrong expression

(3) $\bar{b}\cdot\left(\bar{v}\times\bar{a}\right)c$ scalar

(4) $\left(\left(\left(\bar{c}\times\bar{n}\right)\times\bar{a}\right)\cdot\bar{b}\right)\bar{r}$ vector

(5) $\left(\bar{r}\cdot\bar{a}\right)\times\bar{n}\times\bar{v}$ wrong expression

(6) $\left(\left(\bar{a}\times\bar{n}\right)\cdot\bar{r}\right)\bar{v}\times\bar{n}\,d$ vector

Which of these expressions is

a vector,

a scalar,

a wrong expression ?

Home assignments and final exam: -0.1 points each time you will write a wrong expression