# Honours@UT

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# Programms

- Bachelor honoursprogramms
  - 5 Programmes:
    - Science, Design, Processes of Change, **Math**, Philosophy
  - 30 EC extracurricular
- Bachelor Sterprogrammes (specialization)
  - 30 EC meestal intracurricular
    - IBA, IPA, PSY, CW, IO, TN/AT/EL
- Master honoursprogramms (skills)
  - 20 EC, extracurricular
    - Research, Design, Change Leaders
- “Profielruimte” (3rd year project; no coordinator):
  - 30 EC intracurricular

- As part of the `prestatie afspraken’ the UT needs to attract 7% of its student population into excellence programs
- By 2020 this figure should be 10%.

For its more ambitious students, the University of Twente offers an intense and interesting programme thatchallenges the students to show their best. The programme starts every year in February and is for the top 10% of each study only.

In one and a half year you follow a programme of 30 EC.

As the programme is open for all bachelors, you will work in an interdisciplinary group of excellent and motivated students.

Our honours programmes have a distinctive profile: they are both High Tech and Human Touch. In other words, technique is combined with social sciences. As a student you can develop in one of three roles as a designer, organisor or researcher. The honours programmes stimulate an entrepreneurial attitude with respect towards society and nature.

For these challenging honours programmes, students will be selected who are talented, entrepreneurial and motivated. Also students who want to explore somewhat outside their usual discipline and who want to appeal to their creativity somewhat more are invited to apply.

# The BSc Honours Programme

- Five Programmes:
  - Science,
  - Design,
  - Processes of Change,
  - **Mathematics**,
  - Philosophy

# The Math Track within Honors: six Modules

- Module 1: Linear Algebra and Coding Theory (JWP & BG)
- Module 2: Finding versus Verifying (Bodo Manthey)
- Module 3: Geometry (Gerard Jeurnink)
- Module 4: Signals with Information (Gjerrit Meinsma)
- Module 5: Complex Networks (Nelly Litvak et al)
- Module 6: Dynamic Systems (Mike Boldy)
- Module 6’: Literature Study
  Total Study Load: 30 EC

# Schedule of a module in Math Track

- During 8 weeks:
  Monday 18:15-20:00: Lectures
  Wednesday 18:15-20:00: Tutorials
- Approximately 20 participants from a range of BSc programs such as Industrial Engineering, Technical Physics, Chemical Engineering, Mechanical Engineering, Applied Mathematics, Industrial Engineering and Management, Civil Engineering, etc

# Original Goal

- If you are talented in Math and your interest goes beyond what is taught in your regular courses, then the Excellence Stream might be your choice.
- In the Excellence Stream top students from science and engineering join forces to explore the deeper layers of math, guided by math lecturers and guest professors.
- Subjects may be followed on the basis of standard prior knowledge: first year calculus and linear algebra
- New mathematical subjects, not to be found in standard engineering & science curricula, combined with relevant applications

# 2014: Excellence Stream becomes a track in honours

- Clear advantages:
- organizational
- Access to broader academic sources
- Students can now join the study association Ockham

- On the downside: slight loss of autonomy

# Assessment and success rate

- Homework and other assignments, in the assessment the background of the student is taken into account (what is an excellent student?)
- Drop out rate is about 40%

# Example: linear algebra & coding

- First module of the track
- Runs in parallel to the regular course in linear algebra

- Goal: introduction to linear codes
- Example to motivate: ISBN code, error detection, error correction if position of error is known, need for arithmetic modulo 11
- So far so good, but then: concept of field, back to `mod 11', finite field $Z_p$ . Challenge: serve the diversity of students.
- Vector space over finite field …

# Contents, continued

- Hamming Distance
- Concepts of minumum distance, error correction/detection capability
- Bounds in coding, perfect code
- Hamming codes
- Nearest distance decoding
- Syndrome decoding
- Reed-Solomon codes
- The success story of RS: the CD

# Experiences

- Students like the applications of mathematics
- Quite a few find some concepts rather abstract (e.g. finite field)
- In the end many students appreciate the power of abstraction in the context of applications

# What the lecturers say

- It is fine to teach in the (early) evening (few exceptions)
- The efforts are incorporated in my teaching duties, that’s positive
- The chair is well compensated financially
- The esteem for lecturers of the Math Track should be improved
- Nice that we can choose our subjects within mild limitations

# What the students say

I participate because:

- I am not challenged enough in my own studies
- I want to learn more about mathematics
- I want to be part of the intellectual elite
- I want to enhace my CV
- I have a passion for math
- ….

# Future developments

- Need for reflection on the role of mathematics in general, and in particular the students’ own discipline
- More cohesion across the programme
- History of mathematics
- New subjects (e.g. datascience, topology)
- Individual project at the end of the period of 18 months

- www.utwente.nl/excellentie/en/honours/

# Finding versus verifying (Bodo Manthey)

- For many problems we can find solutions quickly with help of computers. This class of problems is called P. But there are also a large number of problems, where even the fastest computers are not able to solve them. A special class is NP: for these problems we are able to verify whether a solution is correct, but we are not able to find new solutions efficiently.
- Even after 40 years the question remains whether for all problems in NP also solutions can be found efficiently, in other words: P equals NP. This question is one of the millennium problems of the Clay Mathematics Institute. We look at the question whether P equals NP, have a look at why many researchers do not believe that P equals NP and we look at possible consequences of P equals NP and P is unequal to NP.

# Geometry (Gerard Jeurnink)

- Geometry can be build up in different ways. In an axiomatic way it was Euclides (300 BC) who introduced geometric figures that can be constructed by straightedge and compass. This is also our start of the course, but (linear) algebra smooths the later stages of geometry. The resulting analytical geometry gives us the generalisation of planar and solid geometry to higher dimensions. The origin of projective geometry lies in perspective paintings, Italian artists discovered in the 15th century how to draw three-dimensional scenes in correct perspective. All the different types of geometry can be defined by invariants of groups of transformations (Klein, 1872).
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- Prerequisites : Linear Algebra (Math C1)

# SIGNALS WITH INFORMATION (Gjerrit Meinsma)

- **CONTENT**
- *Fast Fourier Transform (FFT)*
- The impact of this in 1965 invented linear operation is unbelievable big. Each laptop calculates for example 250 thousand FFTs per second! And if you would like to multiply two large numbers you also use FFT. JPEG uses FFT as well.
- *Wavelets*
- With Fourier you write the signal as sum of everlasting harmonic functions. That is quite strange, when the signal (e.g. a piece of music) is finitely long. You can look at wavelets as an extension of Fourier, but then one that is closer to the musical notation: the building blocks are of finite length, but we still have limited frequencies. We illustrate wavelets for images and we shall see that spectacular compression ratios can be achieved.
- *Information theory*
- This is maybe the most beautiful example of the force of mathematical modeling. A file with only zeros is easy to compress and if the zeros and ones are alternating often, the compressing becomes more difficult. But how can we understand this mathematically? In this part we provide the basis of the information theory of Claude Shannon. We will see that there is a natural measure for the lack of structure called entropy and that this entropy is equal to the optimal compression ratio.
- You would also like to send files, say, from your router to a laptop and you have a limited amount of information that you can send per unit time. That is what we call (channel)capacity. How do you model this and optimize it? This are we going to cover too and we make the connection with entropy.

# Compex Networks (Nelly Litvak & Nico van Dijk)

- Networks play an increasing role in society. Examples are the internet, social networks, phones networks and electricity and energy networks. Many of these structures have fascinating common properties. In this module we will have a look at the underlying mathematical theory that describes these structures. This theory, random graph theory, studies the collective behaviour of big sets of graphs and can be compared with the ordinary graph theory as statistical physics to the physics of Newton.
- We will look at methods that will show that big networks have peculair properties. Furthermore, we study the time that is needed to let the network perform a certain task (like helping customers in a post office), look at strategies to search for information like Google does and look at how you can effectively spread information (or viruses) in networks. The underlying mathematics is that of random graphs and networks of queues.

# DYNAMIC SYSTEMS (Mike Boldy)

- Most of the concepts used by studying dynamic systems are derived from Birkhoff7. The ideas of Poincaré, Lyapunov and Birkhoff, first developed in finite much dimensions, are generalized to infinite dimensional equations. This type of equations we meet in numerous fields like the fluid dynamics, optics, mathematical biology et cetera. For mathematicians it is a constant challenge to explain and describe patrons that occur in nature by analyzing non-linear dimensional systems.