Potensielt 2-årig internasjonalt masterprogram i akustikk på NTNU

Guillaume Dutilleux og Peter Svensson
NTNU/IE/IES/Akustikk

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Kunnskap for en bedre verden

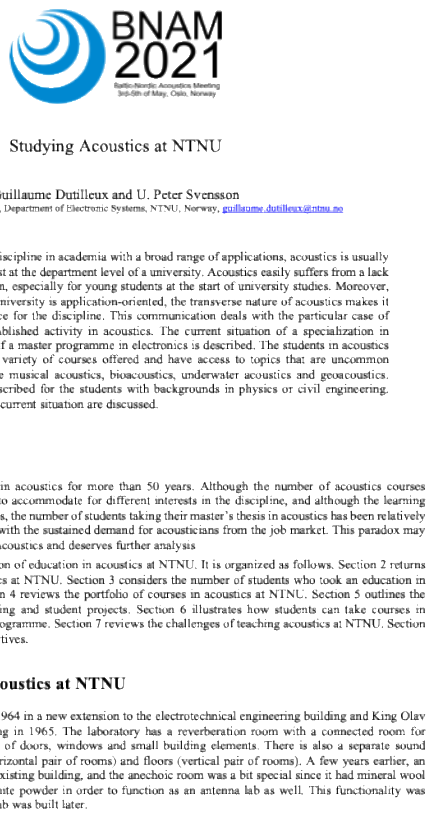
Introduksjon

- NTNU har bred utdanningsportefølje i akustikk
- Industrien skriker etter akustikere siden lang tid
- Det er historisk lav produksjon av akustikere i Norge

- Kan NTNU gjøre noe med det?

Nåværende situasjon

- MTELSYS (hovedprofil i akustikk) på IE
  - 5-årig norsk siv. Ing.
  - Høye opptakskrav
  - Spisset mot mikroelektronikk
  - Lite plass for fysikk/mekanikk i 1.-3. klasse
- MSELSYS (hovedprofil i akustikk) på IE
  - 2-årig internasjonalt
  - Skikkelig masterutdanning i akustikk
  - Presenteres som master i elektronikk
- Enkelte emner på andre fakulteter
  - Bygg: Bygningsakustikk
  - Medisin: Ultralyd
- Tverrfakultetsundervisning er vanskelig



BNAM 2021
Baltic-Nordic Acoustics Meeting
3rd-5th of May, Oslo, Norway

Studying Acoustics at NTNU

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While it is a well established discipline in academia with a broad range of applications, acoustics is usually not big enough a subject to exist at the department level of a university. Acoustics easily suffers from a lack of visibility in higher education, especially for young students at the start of university studies. Moreover, when the organization of the university is application-oriented, the transverse nature of acoustics makes it difficult to find a suitable place for the discipline. This communication deals with the particular case of NTNU which has a long established activity in acoustics. The current situation of a specialization in acoustics under the umbrella of a master programme in electronics is described. The students in acoustics at NTNU can benefit from a variety of courses offered and have access to topics that are uncommon elsewhere in Scandinavia, like musical acoustics, bioacoustics, underwater acoustics and geoacoustics. Alternative tracks are also described for the students with backgrounds in physics or civil engineering. Potential improvements to the current situation are discussed.

1 Introduction

NTNU has been offering education in acoustics for more than 50 years. Although the number of acoustics courses proposed by NTNU is large enough to accommodate for different interests in the discipline, and although the learning environment offers many opportunities, the number of students taking their master's thesis in acoustics has been relatively low in the past years. This is at odds with the sustained demand for acousticians from the job market. This paradox may be related to the transverse nature of acoustics and deserves further analysis

This paper reviews the current situation of education in acoustics at NTNU. It is organized as follows. Section 2 returns to the origins of education in acoustics at NTNU. Section 3 considers the number of students who took an education in acoustics in the past 20 years. Section 4 reviews the portfolio of courses in acoustics at NTNU. Section 5 outlines the experimental facilities used in teaching and student projects. Section 6 illustrates how students can take courses in acoustics, depending on their study programme. Section 7 reviews the challenges of teaching acoustics at NTNU. Section 8 brings some conclusions and perpectives.

2 A bit of history of acoustics at NTNU

An acoustics laboratory was built in 1964 in a new extension to the electrotechnical engineering building and King Olav V was visiting for an official opening in 1965. The laboratory has a reverberation room with a connected room for measurements of sound transmission of doors, windows and small building elements. There is also a separate sound transmission laboratory for walls (horizontal pair of rooms) and floors (vertical pair of rooms). A few years earlier, an anechoic room had been built in the existing building, and the anechoic room was a bit special since it had mineral wool wedges that were covered with graphite powder in order to function as an antenna lab as well. This functionality was rarely used since a separate antenna lab was built later.

NTNU

Behov for akustikere i Norge

Vi har estimert behovet for tre typer av akustiker i Norge

- "**Konsulentprofil**" (rom- og bygningsakustikk, miljøakustikk, støy,…).
  Minst 360 personer I slike jobb idag
  -> behov for 10-12 nye personer/år
- "**ELSYS-profil**" (elektroakustikk, akustikksignalbehandling inkl. undervannsakustikk)
  -> behov for ≈ 5 nye personer/år
- **Ultralyds-profil** (medisinsk og industriell ultralyd)
  -> behov for ≈ 5 nye personer/år

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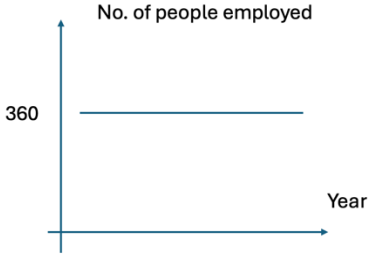
Enkle å identifisere og telle

Ikke så enkle å identifisere og telle

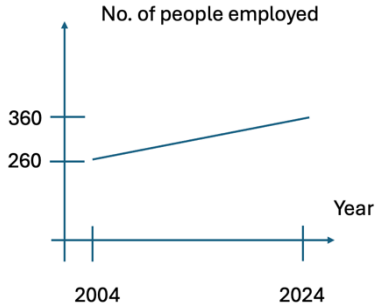
Behov for akustikere i Norge – matematisk modell

Modell 1: Status quo økning



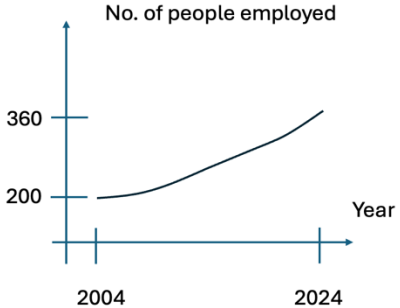
9 nye personer trenges:
9 slutter
0 nye jobb

Modell 2: Lineær økning



10 nye personer trenges:
5 slutter
5 nye jobb

Modell 3: > lineær



13 nye personer trenges:
(for en av mange modeller)
4.5 slutter
9 nye jobb

Antar i snitt
40 år i jobb

"Fasit": vi har tellt 316 personer som har startet i akustikkjobb under 2000-2024 (med "konsulentprofil"), dvs 13 per år ⇒ enkle modeller kanskje greit for estimat.

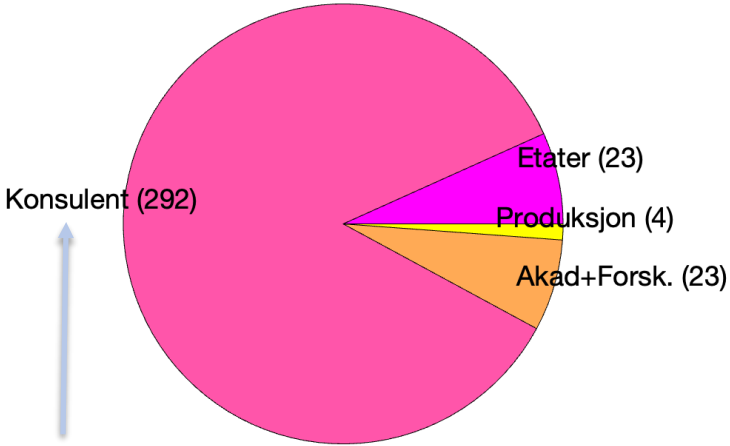
Hvor jobber akustikerne (med "konsulentprofil") i Norge?

4 konsulentbedrifter med > 25 akustiker har 64% av alle

4 konsulentbedrifter har 10-24 akustiker

6 konsulentbedrifter har 2-9 akustiker

12 enpersonskonsulenter

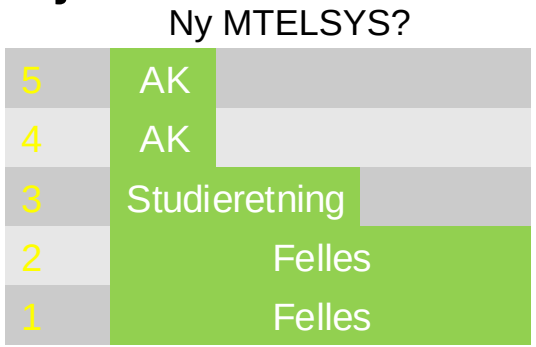


Sum: 342

Inkluderer 23 personer fra offshore konsulentbedrifter

2-årig master - prinsipper

- Minst 15 SP i akustikk per semester
- Samkjøring med MTELSYS hovedprofil i Akustisk signalbehandling og kommunikasjon



Innhold og spesialiseringer - 1

O: obligatorisk
V: valgbar

Akustikk i bygget miljø

S10	Masteroppgave			
S09	Fordypningsprosjekt		O:Akustikk i bygget miljø	V: Bioakustikk for biodiv.
S08	O: Akustisk måleteknikk	V: Akustiske omvandlere	V:	Eksperter i Team
S07	O: Oppdag akustikk	V: Akustisk signalbehandling	O: Bygningsakustikk	V:

Marin akustikk

S10	Masteroppgave			
S09	Fordypningsprosjekt		O: Marin akustikk (ny)	V: Bioakustikk for biodiv.
S08	V: Akustisk måleteknikk	O: Akustiske omvandlere	V:	Eksperter i Team
S07	O: Oppdag akustikk	O: Akustisk signalbehandling	V:	V;

Innhold og spesialiseringer - 2

O: obligatorisk
V: valgbar

Akustikk for audio, musikk og multimedia

S10	Masteroppgave			
S09	Fordypningsprosjekt		O: Musikakustikk og romakustikk	V
S08	V: Akustisk måleteknikk	O: Akustiske omvandlere	V:	Eksperter i Team
S07	O: Oppdag akustikk	O: Akustisk signalbehandling	V:	V:

Industriell ultralyd (i samarbeid med NTNU/MH)

S10	Masteroppgave			
S09	Fordypningsprosjekt		O: Avansert akustikk	V:Bioakustikk
S08	O: Akustiske omvandlere	V:	V:	Eksperter i Team
S07	O: Oppdag akustikk	V: Akustisk signalbehandling	O: Signalbehandling i ultralyd-avildning	V:

TTT4181 – Oppdag akustikk

- Masse-fjær systemer

- Strings and bars
- Membraner

- Bølgeligning
- Plane/sylindriske/sfæriske bølger
- Refleksjon og transmisjon
- Utstråling og mottakelse
- Cavities and waveguides

- Avanserte temaer
  - Diffraksjon
  - Absorpsjon i fluider
  - Strømning og aeroakustikk
  - Ikke-lineær akustikk
  - Ikke symmetriske problemer

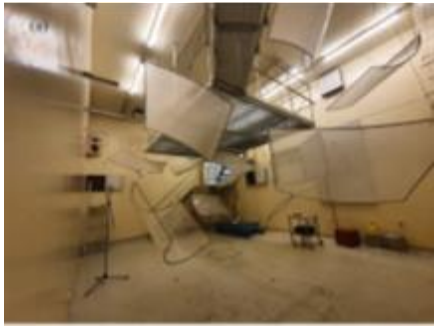
- Bruk av numeriske metoder

TTT4295 – Akustisk signalbehandling

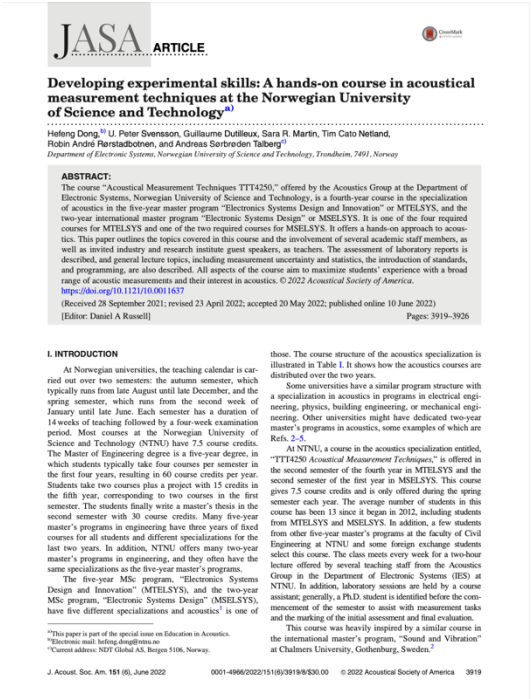
- Signaler og systemer
- Transducere, introduksjon
- Arrayprosessering
- Hørsel
- Syntese av signaler
- Maskinlæring i akustikk

TTT4250 – Akustisk måleteknikk

- Labbasert emne



- Lydeffekt
- Kildedirektivitet
- Lyddemping
- Absorpsjonsfaktor
- Hørsel



JASA ARTICLE

Developing experimental skills: A hands-on course in acoustical measurement techniques at the Norwegian University of Science and Technology[a)]

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ABSTRACT:
The course "Acoustical Measurement Techniques TTT4250," offered by the Acoustics Group at the Department of Electronic Systems, Norwegian University of Science and Technology, is a fourth-year course in the specialization of acoustics in the five-year master program "Electronics Systems Design and Innovation" or MTELSYS, and the two-year international master program "Electronic Systems Design" or MSELSYS. It is one of the four required courses for MTELSYS and one of the two required courses for MSELSYS. It offers a hands-on approach to acoustics. This paper outlines the topics covered in this course and the involvement of several academic staff members, as well as invited industry and research institute guest speakers, as teachers. The assessment of laboratory reports is described, and general lecture topics, including measurement uncertainty and statistics, the introduction of standards, and programming, are also described. All aspects of the course aim to maximize students' experience with a broad range of acoustic measurements and their interest in acoustics. © *2022 Acoustical Society of America*.
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I. INTRODUCTION

At Norwegian universities, the teaching calendar is carried out over two semesters: the autumn semester, which typically runs from late August until late December, and the spring semester, which runs from the second week of January until late June. Each semester has a duration of 14 weeks of teaching followed by a four-week examination period. Most courses at the Norwegian University of Science and Technology (NTNU) have 7.5 course credits. The Master of Engineering degree is a five-year degree, in which students typically take four courses per semester in the first four years, resulting in 60 course credits per year. Students take two courses plus a project with 15 credits in the fifth year, corresponding to two courses in the first semester. The students finally write a master's thesis in the second semester with 30 course credits. Many five-year master's programs in engineering have three years of fixed courses for all students and different specializations for the last two years. In addition, NTNU offers many two-year master's programs in engineering, and they often have the same specializations as the five-year master's programs.

The five-year MSc program, "Electronics Systems Design and Innovation" (MTELSYS), and the two-year MSc program, "Electronic Systems Design" (MSELSYS), have five different specializations and acoustics[1] is one of those. The course structure of the acoustics specialization is illustrated in Table I. It shows how the acoustics courses are distributed over the two years.

Some universities have a similar program structure with a specialization in acoustics in programs in electrical engineering, physics, building engineering, or mechanical engineering. Other universities might have dedicated two-year master's programs in acoustics, some examples of which are Refs. 2–5.

At NTNU, a course in the acoustics specialization entitled, "TTT4250 *Acoustical Measurement Techniques*," is offered in the second semester of the fourth year in MTELSYS and the second semester of the first year in MSELSYS. This course gives 7.5 course credits and is only offered during the spring semester each year. The average number of students in this course has been 13 since it began in 2012, including students from MTELSYS and MSELSYS. In addition, a few students from other five-year master's programs at the faculty of Civil Engineering at NTNU and some foreign exchange students select this course. The class meets every week for a two-hour lecture offered by several teaching staff from the Acoustics Group in the Department of Electronic Systems (IES) at NTNU. In addition, laboratory sessions are held by a course assistant; generally, a Ph.D. student is identified before the commencement of the semester to assist with measurement tasks and the marking of the initial assessment and final evaluation.

This course was heavily inspired by a similar course in the international master's program, "Sound and Vibration" at Chalmers University, Gothenburg, Sweden.[2]

[a)]This paper is part of the special issue on Education in Acoustics.
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TTTYYYY – Akustiske omvandlere

- Omvandlererteknologier (elektrodynamisk, elektrostatisk, piezoelektrisk osv)
- Analogier for analyse av omvandlere
- Lineæritet, tidsvariansegenskaper, signal-støyforhold
- Direktivitetsegenskaper
- Distribuerte målesystemer, synkronisering

TTT4285 - Akustikk i bygget miljø

Romakustikk

- Refleksjon, absorpsjon, diffraksjon
- Måleteknikk
- Analyse/beregningsmodeller: diffusfelt, geometrisk akustikk, bølgeteoretisk
- Psykoakustikk/oppfattelse

- Simuleringsoppgave

Miljøaksutikk

- Trafikkstøy (vei, tog, fly)
- Industristøy
- Vindturbinstøy
- Lydutbredelse
- Støyindikatorer
- Helsepåvirkninger

- Målings- og simuleringsoppgave

Konklusjon - 2-årig master i akustikk på NTNU?

- Akustikk kunne synliggjøres på NTNU
- Lettere tilgang for studenter med bakgrunn utenfor elektro
- Effektivisert struktur med tilbud tilpasset til ulike bransjer

- Samkjøring med MTELSYS
- Ønsket samarbeid med andre fakulteter, for akustikk er tverrfaglig

- Fortsatt mye å gjøre før programmet blir godkjent
- Har vi glemt noe?