



MWL

The Marcus Wallenberg Laboratory
for Sound and Vibration Research

COURSE INFORMATION – NON-LINEAR VIBRATIONS 2019

Code: SD3180

Credits: 7.5

Lecturer and examiner: Leif Kari 070-798 7974 leifkari@kth.se

Prerequisites: Undergraduate courses in mechanics and mathematics.

Motivation: Non-linear phenomena are of fundamental importance in engineering and science – particularly within the field of vibrations and acoustics. These phenomena include shock wave development, self-sustaining oscillations, super- and sub-harmonic responses, to mention a few. Although significant research progress is attained during the last years, covering non-linear ideas, analytical methods, numerical and physical experiments of major mathematical and physical interest, there are still only a few courses devoted to non-linear phenomena and methods – particularly in the vibration and acoustical field. The primary purpose of this course is to fill that.

Outline: This course is learning-centered, supporting a view of learners as active participants in their own learning while using continuous formative assessments with no need for a final examination. To this end, the learners are supposed to take active part in the lectures; encompassing active discussions and experimentations – to mention a few – but also involving active reflective observations while promoting creative solutions.

Contents: Conservative and non-conservative systems, forced oscillations of systems, continuous systems and traveling waves.

Methods: Perturbation methods – such as straightforward expansion, Lindstedt-Poincaré method, method of multiple scales, method of harmonic balance, method of averaging – and basic numerical methods.

Objectives:

After the course, the participant shall be able to:

- Apply perturbation methods to new situations:
 - Predict the response of a novel, non-linear system – approximated by a conservative, finite degree-of-system – using a perturbation method.
 - Predict the response of a novel, non-linear system – approximated by a non-conservative, finite degree-of-system – using a perturbation method.
 - Calculate all the resonance frequencies of a forced, novel, non-linear system – approximated by a non-conservative, single degree-of-system – using a perturbation method.
 - Demonstrate a correct use of a perturbation method in the prediction of the standing wave response of a novel, non-linear continuous system – such as string, beam, plate or shell.
 - Predict the travelling wave response of a novel, non-linear continuous system using a perturbation method.

- Analyze non-linear acoustic phenomena:
 - Identify the non-linear phenomena for finite degree-of-freedom systems.
 - Point out the reasons for the non-linear phenomena for finite degree-of-freedom systems.
 - Identify the non-linear phenomena for continuous systems.
 - Point out the reasons for the non-linear phenomena for continuous systems.

- Judge the value of applied perturbation methods for a given application:
 - Write a short exposition evaluating the relative merits of the applied perturbation methods.
 - Compare the response results predicted by a perturbation method with those of a basic numerical method.
 - Explain the reasons for a good match between results obtained by a perturbation method and those of a basic numerical method.
 - Explain the reasons for any mismatch between results obtained by a perturbation method and those of a basic numerical method.

- Display a scientific attitude towards non-linear problems:
 - Demonstrate curiosity in identifying non-linear problems.
 - Seek natural causes of non-linear phenomena.
 - Demonstrate open-mindedness when seeking solutions.
 - Suspend judgments until all evidence is available.
 - Show objectivity in analyzing evidence and drawing conclusions.
 - Show willingness to revise conclusions as new evidence becomes available.

Home assignments:

The learning outcomes are continuously assessed by totally about 4-5 home assignments where methods learned and skills developed during the course are applied to *new* situations while requiring both analyzing and evaluation of the results and methods used. It is permissible to cooperate on the assignments, but they must be handed in individually and written in pencil (no computer print outs).

Scientific paper review:

A recently published scientific paper using some of the method learned is individually reviewed during the final part of the course. The method used and results shown are critically evaluated while also suggesting some alternative approaches. The results of this review are given at a seminar and in a short individual report – covering approximately one to two A4 papers.

Grading scale:

P, F

Examination: No final examination.

- Approved home assignments handed-in in time (INL1)
- Approved scientific paper review seminar and report (PRO1)

INL1 - Assignment, 6.0 credits, Grading scale: G

PRO1 - Project work, 1.5 credits, Grading scale: G

Evaluation: Formative and summative course evaluations are to be used.

Literature: “Non-linear Acoustics” Leif Kari – lecture notes

"Nonlinear Oscillations" by AH Nayfeh & DT Mook,
John Wiley & Sons, ISBN: 0471035556, 1979 (Hardcover) or
Wiley Classics Library, ISBN: 0471121428, 1995 (Paperback)

Reference literature:

"Perturbation Methods" by AH Nayfeh,
John Wiley & Sons, ISBN: 0471630594, 1973 (Hardcover) or
Wiley Classics Library, ISBN: 0471399175, 2000 (Paperback)

"Linear and Nonlinear Waves" by G.B. Whitham,
John Wiley & Sons, ISBN: 0471940909, 1974 (Hardcover) or
Wiley-Interscience, ISBN: 0471359424, 1999 (Paperback)

"Introduction to Perturbation Techniques" by AH Nayfeh,
John Wiley & Sons, ISBN: 0471080330, 1981 (Hardcover) or
Wiley Classics Library, ISBN: 0471310131, 1993 (Paperback)

Course material:

Covered mainly by “Non-linear Acoustics” Leif Kari – lecture notes

Preliminary program:

Le – Lesson, LK – Leif Kari

Nr	Time	Place		Program (<i>Preliminary</i>)
Le 1	Mon 26 Aug 10-12	MUNIN ¹	LK	Information Chapter 1 – Introduction
Le 2	Fri 30 Aug 15-17	BALDER ²	LK	Chapter 2 – Conservative Systems
Le 3	Mon 23 Sep 15-17	MUNIN	LK	Continued
Le 4	Wed 25 Sep 8-10	MUNIN	LK	Continued
Le 5	Thu 26 Sep 17-19	BALDER	LK	Chapter 3 – Non-Conservative Systems
Le 6	Fri 4 Oct 13-15	MUNIN	LK	Chapter 4 – Forced Systems
Le 7	Fri 4 Oct 15-17	MUNIN	LK	Chapter 5 – Waves in Continuous Systems
Le 8	Wed 9 Oct 15-17	MUNIN	LK	Continued
Le 9	Thu 10 Oct 15-17	MUNIN	LK	Continued
Le 10 (Sem)	To be decided	-----	LK	Review seminar

Questions: Leif Kari is available for answering questions arising before, during or after the course.

MOST WELCOME!

¹ Room Munin, Teknikringen 8, ground floor

² Room Balder, Teknikringen 8, 3rd floor