MWL The Marcus Wallenberg Laboratory for Sound and Vibration Research

COURSE INFORMATION – NON-LINEAR ACOUSTICS 2017

Code: SD2180

Credits: 6

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 void.

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: The general instructional objectives, stated as intended learning outcomes in student performance terms, together with those of specific learning outcomes, incorporate:

For all grades:

1. Applies perturbation methods to new situations:
   i. Predicts the response of a novel, non-linear system – approximated by a conservative, finite degree-of-system – using a perturbation method.
   ii. Predicts the response of a novel, non-linear system – approximated by a non-conservative, finite degree-of-system – using a perturbation method.
   iii. Calculates all the resonance frequencies of a forced, novel, non-linear system – approximated by a non-conservative, single degree-of-system – using a perturbation method.
   iv. Demonstrates 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.
   v. Predicts the traveling wave response of a novel, non-linear continuous system using a perturbation method.

2. Analyzes non-linear vibration phenomena:
   i. Identifies the non-linear phenomena for finite degree-of-freedom systems.
   ii. Points out the reasons for the non-linear phenomena for finite degree-of-freedom systems.
   iii. Identifies the non-linear phenomena for continuous systems.
   iv. Points out the reasons for the non-linear phenomena for continuous systems.

3. Judges the value of applied perturbation methods at a given application:
   i. Writes a short exposition evaluating the relative merits of the applied perturbation methods.
   ii. Compares the response results predicted by a perturbation method with those of a basic numerical method.
   iii. Explains the reasons for a good match between results obtained by a perturbation method and those of a basic numerical method.
   iv. Explains the reasons for any mismatch between results obtained by a perturbation method and those of a basic numerical method.

For grades A, B and C:

4. Displays a scientific attitude towards non-linear problems:
   i. Demonstrates curiosity in identifying non-linear problems.
   ii. Seeks natural causes of non-linear phenomena.
   iii. Demonstrates open-mindedness when seeking solutions.
   iv. Suspends judgments until all evidence is available.
   v. Shows objectivity in analyzing evidence and drawing conclusions.
   vi. Shows willingness to revise conclusions as new evidence becomes available.

Home assignments: (All students)

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: (For grade A, B and C students)

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.

Examination: No final examination.
TEN1 - Examination, 6.0 credits

- Approved home assignments results in grade D or E (normally D)
- Approved home assignments handed-in in time, scientific paper review seminar and report results in grade A, B or C (normally B). The better the seminar and report, the higher is the grade.

Grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Other requirements for final grade:
Written home assignments (TEN1; 6 university credits).

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 – Lession, LK – Leif Kari

Nr	**Time**	**Place**		**Program** (*Preliminary*)
Le 1	Mon 4 Sep 8-10	MUNIN [1]	LK	Information **Chapter 1 –** Introduction
Le 2	Wed 6 Sep 13-15	MUNIN	LK	**Chapter 2 –** Conservative Systems
Le 3	Mon 11 Sep 8-10	MUNIN	LK	Continued
Le 4	Wed 13 Sep 13-15	MUNIN	LK	Continued
Le 5	Mon 18 Sep 8-10	MUNIN	LK	**Chapter 3** – Non-Conservative Systems
Le 6	Wed 20 Sep 13-15	MUNIN	LK	**Chapter 4** – Forced Systems
Le 7	Mon 25 Sep 8-10	MUNIN	LK	**Chapter 5 –** Waves in Continuous Systems
Le	Wed ~~27 Sep 13-15~~	~~MUNIN~~	~~LK~~	**Cancelled**
Le 8	Mon 2 Oct 8-10	MUNIN	LK	Continued
Le 9	Wed 4 Oct 13-15	MUNIN	LK	Continued
Le 10 (Sem)	To be decided	MUNIN	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