MF2068 Machine dynamics (6cr)

Course-PM

Autumn 2021

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Canvas activity: ***MF2068 HT21-1 Machine Dynamics***

KTH Maskinkonstruktion

Department of Machine Design
School of industrial engineering and management
KTH Royal Institute of Technology

Background

The purpose of the dynamics of machinery, or machine dynamics, is to apply the knowledge from the field of dynamics to specific problems in engineering. Its development is closely linked to developments in mechanical engineering. Dynamic problems are observed in power and work machines, and torsional vibrations play an important role in reciprocating engines, and bending vibrations put turbine components at risk.

Knowledge of the dynamics of machinery is not only required for explaining related dynamic phenomena but also for designing machines based on dynamic principles, such as hammers, robots, oscillating conveyors, centrifuges. Dynamic problems have stepped into the foreground with the ever-increasing operating speed and the enforcement of lightweight design principles in all fields of processing machines, agricultural machines, machine tools, printing machines, and conveyors. To manage their multiplicity, defining and answering the basic questions has become necessary while abstracting as much as possible from any specific machine. In this way, the dynamics of machinery has grown into an independent discipline that should be part of the toolset of every mechanical engineer.

Aim

The course presents the theory of machine dynamics, how to model and simulate the dynamic behaviour of machine systems in the time domain and in the frequency domain, and how to transform the response between those domains. The course also introduces knowledge on how to estimate dynamic properties from vibration and load measurements. Furthermore, dynamic parameter identification and inverse modeling techniques and methods are taugth and practiced.

A student that has completed the course shall:

- be able to model the dynamic behaviour in the time domain of machine components and systems with Matlab and Ansys;
- be able to reason on how to perform measurements of the dynamic behaviour of a machine system;
- be able to analyse the frequency content of a measured dynamic behavior;
- be able to reason on how to identify dynamic system properties from measurements;

Course components

Effect from the Covid-19 pandemic, and an aim to keep social distancing, is that lectures and scheduled supervisions will be digital, each with a dedicated virtual room in Zoom. Links to the Zoom rooms can be found in the module "Virtual meeting rooms (in chronological order)" that is available in the Canvas course activity "MF2068 HT21-1 Machine Dynamics". All students registered to the course automatically become members of the Canvas activity.

Each of the five computer exercises is scheduled in two computer rooms on campus.

- Lectures (9 x 2 hours):

  Lectures on machine dynamics topics, all digital in Zoom

- Computer exercises (5 x 2 hours):

  Computer-based exercises on topics introduced at preceeding lecture(s).

  Each computer exercise is performed individually, and the results must be documented, uploaded to Canvas, and approved. The computer exercises are supervised on campus in the computer class rooms (Glader and Prosit).

- Supervisions (3 x 2 hours):

  Supervision of four (2+1+1) computer exercise tasks, each in a dedicated virtual Zoom room

- Seminar (2 hours):

  One re-cap seminar in a dedicated Zoom room

- Written exam (5 hours) – physical presence in lecture rooms (TBC).

Examination

Final grading (A-F) is based on the result in the written exam but requires approved deliverables to all five exercises.

Prerequisites

The course is at an advanced level, and the prerequisite is a Bachelor in Mechanical Engineering or similar.

Student preparation for using Zoom

Most of you have, more or less, been using Zoom before. If not:

- Carefully read the instructions for Zoom that is available in https://intra.kth.se/en/utbildning/e-larande/webbmoten/webbmoten-med-zoom-1.836430
- Install the app/client and check that it works. https://kth-se.zoom.us
  You are encouraged to try by connecting with a fellow student or a friend. There is also a feature so you can check your audio settings.
- You should use your individual computer with a decent internet connection. It works much better if you have one computer each, rather than sharing one computer between two or more students. This also applies if you want to organize smaller Zoom meetings with your mates. If you do not have a laptop or similar, you should contact it-support@kth.se.

- You should use a headset with a microphone. Regular iPhone headset and alike works fine. When your microphone is turned off (preferably from within Zoom) you need no microphone or headset, IF THERE IS NO SIGNIFICANT BACKGROUND NOISE WHERE YOU ARE.
- We prefer that you have your camera enabled so we can see you, but if you don't have a camera or webcam on your computer, or if you are very uncomfortable with it, that's also ok.

The first virtual meeting in MF2068, i.e. Lecture 1 on Monday, August 30 @10:15, but you should sign in already at 10:00 so you have time to ensure that everything is working (especially audio setting).

- You will find a link to the virtual lecture on top in the Canvas Module folder "Virtual meeting rooms (in chronological order)". Just click on the link to enter the Zoom meeting room. If have not installed the zoom app or client, it will work in most web browsers.
- The responsible for the course is the Host for the virtual meeting.
- As default, your microphones are turned off, but you may toggle the Mute/Unmute icon, which is the leftmost icon at the bottom of the Zoom screen.
- The chat function within zoom is enabled so you can type comments/questions, just like in Messenger.
- The lecturer might not be able to respond to your comments/questions in the chat during the lecture, but there will be an opportunity for oral questions at the end.

Course literature

1. Course material on basic dynamics, modal analysis and FEM-based dynamic analysis in the Canvas *MF2068 HT20-1* module folder *Literature – Colorado*.
2. H. Dresig, F. Holzweissig, "Dynamics of machinery". Springer, ISBN 978-3-54089939-6, e-ISBN 978-3-540-89940-2 2010. E-book @ the KTH Library: http://link.springer.com.focus.lib.kth.se/chapter/10.1007/978-3-540-89940-2_1 . Also in the Canvas *MF2068 HT20-1* module folder *Literature – Dynamics of machinery*

Teachers

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Schedule, Autumn 2021

	Period 1 (weeks 35 – 43 2019)	Time	Location	Lecture (L)/ Computer lab (C)/ Supervision (H), or seminar (S)
W35	Monday 30 Aug	10-12	Zoom	L1: Introduction to machine dynamics and dynamics of machines
W36	Monday 6 Sept	10-12	Zoom	L2: SDOF systems
	Wednesday 8 Sept	10-12	Glader, Prosit + Zoom	C1: Matlab-based analysis of an SDOF system
W37	Monday 13 Sept	10-12	Zoom	L3: MDOF systems
	Wed. 15 Sept	10-12	Glader, Prosit + Zoom	C2: Matlab-based model analysis of an MDOF system
	Friday 17 Sept	10-12	Zoom	H1: Supervision of C1 and C2
W38	Monday 20 Sept	10-12	Zoom	L4: Modal analysis of MDOF systems
	Tuesday 21 Sept	10-12	Glader, Prosit + Zoom	C3: Matlab-based modal analysis
	Wed. 22 Sept	10-12	Zoom	H2: Supervision of C3
	Friday 24 Sept	10-12	Zoom	L5: Model parameter identification & inverse dynamic modeling
W39	Monday 27 Sept	10-12	Zoom	L6: Dynamics of machines
	Tuesday 28 Sept	13-15	Glader, Prosit + Zoom	C4: Inverse modeling of back-to-back rig
	Wed. 29 Sept	10-12	Zoom	H3: Supervision of C4
	Friday 30 Sept	13-15	Zoom	L7: MDOF forced and damped machine systems
W40	Monday 4 Oct	10-12	Zoom	L8: The Finite Element Method for dynamic multibody analysis
	Wed. 6 Oct	10-12	Glader, Prosit + Zoom	C5: Ansys-based dynamic modeling and simulation
W41	Monday 11 Oct.	10-12	Zoom	L9: Dynamically favourable designs
	Wed. 13 Oct.	10-12	Zoom	S: Course re-cap seminar
W43	Wed. 27 Oct	14-18	M36, M37, M38	Written exam

Preparation to	To read in: 1 – D&H (Dresig & Holzweissig, "Dynamics of Machinery") 2 – Colorado (Colorado IAST course notes)	Pages to read	To do after lecture
Lecture 1: Introduction	**D&H Purpose and structure of the dynamics of machinery** **D&H Chapter 1.1: Classification of calculation models**	**1-4** **5-13**	
Lecture 2: SDOF systems	**Colorado: IAST.Lect17 – Free single-DOF oscillator** **Colorado: IAST.Lect18 – Harmonically forced SDOF oscillator**	**17-1 – 17-11** **18-1 – 18-7**	**Exercise C1**
Lecture 3: MDOF systems	**Colorado: IAST.Lect19 – MDOF dynamic systems**	**19-1 – 19-10**	
Lecture 4: Modal analysis of MDOF systems	**Colorado: IAST.Lect20 – Modal analysis of MDOF unforced undamped systems**	**20-1 – 20-9**	**Exercise C2**
Lecture 5: Model parameter identification and inverse dynamic modeling	**D&H Chapters 1.2-1.5: Mass, spring, damping, excitation**	**14-65**	**Exercise C3**
Lecture 6: MDOF forced damped systems	**Colorado: IAST.Lect21 – Modal analysis of MDOF forced undamped systems** **Colorado: IAST.Lect22 – Example analysis of MDOF forced damped systems**	**21-1 – 21-11** **22-1 – 22-11**	**Exercise C4**
Lecture 7: Dynamics of machines	**D&H Chapters 4:Torsional oscillators and longitudinal oscillators** **D&H Chapters 5:Bending oscillators** **D&H Chapters 7:Simple nonlinear and self-excited oscillators**	**223-310** **311-354** **465-504**	
Lecture 8: FEM for dynamic MDOF analysis			**Exercise C5**
Lecture 9: Dynamically favourable designs	**D&H Chapter 8: Rules for dynamically favourable designs**	**505-510**	