Course Information
TMME40 Vibration Analysis of Structures
6hp

Lectures: 27h
Tutorials: 13h
Computer laborations: 4h

Examiner
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Course Homepage:
www.solidmechanics.iei.liu.se/Examiners/Courses/Master_Level/tmme40/

Course Objectives
After completing the course, the student is expected to be able to:

- model simple and more complex mechanical systems;
- define the basic concepts in structural dynamics as velocity, acceleration, force, couple, energy, frequence, period, damping factor, excitation, system characteristics, response;
- perform simple derivations of theorems and expressions used in the course;
- use modal analysis, approximate and exact methods, solve for frequences and eigenmodes for different structures;
- use Lagranges equations to obtain the govering equations for a structure, and solve these analytically or numerically;
- determine the type of stability for simple non-linear systems.

Examination
The examination consists of hand-in assignments. The assignments can give 20 points in total and to pass the examination the student must have a minimum of 10 point. Grades are given according to:

3(ECTS C): 10–13p; 4(ECTS B): 14–17p; 5(ECTS A): 18–20p.

The exam assignments will be published Friday 19 October and the dead-line for submitting the solutions is Friday 2 November at 12:00. The solutions are to be handed in as **paper-copies** following the instruction on the assignments. E-mail submission is not accepted. Please read the specific instruction on the assignments. Hand-written solutions are accepted if they are neatly written.

Re-exams are given in January and August. Students who are interested in taking the re-exam should notify the examiner by email well in advance.

All assignments are to be solved and reported individually. It is not allowed to solve the assignments in groups or copy solutions from other students, the internet, books etcetera, or otherwise attempt to deceive during the examination. If results, figures, theory etc. are taken from other sources, this must be clearly indicated, e.g., by citing the source. Failure to comply with these rules will result in a report to the Disciplinary Board at Linköping University. For more information regarding cheating and disciplinary measures, contact the examiner or see the student internet pages https://www.student.liu.se/studenttjanster/lagar-regler-rattigheter?l=en.

Course Literature

Daniel J. Inman. *Engineering Vibrations. Fourth Edition, International Edition.* Pearson, 2014 + additional material handed out during the course.

Selected References (non-obligatory)

William J. Bottega. *Engineering Vibrations. Second Edition.* CRC Press, 2015
Leonard Meirovitch. *Fundamentals of Vibrations. International Edition.* McGraw-Hill, 2001
Hans Lundh. *Grundläggande hållfasthetslära.* Instant Book AB, Stockholm, 2013 (Ch. 17, in Swedish)
Clarence W. de Silva. *Vibration. Fundamentals and Practice.* CRC Press, 2000
Singiresu S. Rao. *Mechanical Vibrations. Sixth Edition.* Pearson, 2017
Alok Sinha. *Vibration of Mechanical Systems.* Cambridge University Press, 2010

Course Structure

Class	Lecture(Le)/ Tutorial(T)/ Lab(Lab)	Chapter/Exercises
1	Le:1	Ch. 1.1-1.2, 1.4-1.5 + Appendix A
2	Le:2	Ch. 1.3, 1.10, (1.6-1.7)
3	T:1	
4	Le:3	Ch. 2.1-2.2, 2.4-2.5, 2.7
5	Le:4	Ch. 3.1-3.4 + Appendix B + extra material
6	T:2	
7	Le:5/T:3	Ch. 1.8-1.9, 2.8-2.9, 3.9-3.10
8	Le:6	Ch. 8
9	Lab:1 (FEM)	
10	Le:7	Ch. 4.1 + Appendix C
11	Le:8	Ch. 4.2-4.4
12	T:4	
13	Le:9	Ch. 4.5-4.6
14	T:5	
15	Le:10	Ch. 4.7-4.9
16	Le:11	Extra material on approximative methods
17	T:6	
18	Le:12	Ch. 6.1-6.5, 6.7-6.8
19	T:7	
20	Le:13	Ch. 8
21	Le:14	Ch. 8
22	Lab:2 (FEM)	

Tabell 1: Plan for lectures, tutorials and computer labs.

Suggested Exercises

Tutorial	Exercises
1	1.7, 1.11, 1.13, 1.21, 1.27, 1.35, 1.37[1], 1.40, 1.42, 1.43, 1.46[2], 1.47, 1.55, 1.57, 1.63, 1.67, 1.82, 1.84[3], 1.86
2	2.3[4], 2.4[5], 2.6, 2.8, 2.15[6], 2.21, 2.27, 2.36[7], 2.47, 2.54, 2.60, 2.63, 2.86, 3.2, 3.3, 3.8, 3.10, 3.20, 3.22, 3.32, 3.35, 3.39, 3.41
3	1.111, 1.113, 1.126(use Matlab), 1.128(use Matlab), 2.90(use Matlab), 2.97[8](use Matlab), 3.64, 3.68(use Matlab)
4	4.1, 4.2, 4.3, 4.9, 4.12, 4.20, 4.22[9], 4.38, 4.39, 4.49, 4.57
5	4.60, 4.68,4.77
6	4.84, 4.86, 4.100(Matlab), 4.104[10](use Matlab)
7	6.5, 6.6, 6.9, 6.14, 6.15[11], 6.32, 6.33[12], 6.42, 6.46, 6.56[13], 6.66

Tabell 2: Suggested exercises for the tutorials.

[1] Treat the wheel as a point mass

[2] Determine the relationship in Window 1.5.

[3] The mass moment of inertia is $I = 12$ kg·m^2.

[4] Compute the equivalent mass, see Ch. 1.5. Assume the forcing $F = F_0 \cos(\omega t)$.

[5] $x(t) = \frac{2f_0}{\omega_n^2 - \omega^2} \sin \frac{\omega t + \omega_n t}{2} \sin \frac{\omega_n t - \omega t}{2}$

[6] The effect of the wind speed u is replaced by a moment $M_0 \cos \omega t$ around the pivot point.

[7] Use $k = 2000$ Nm/rad and $J = 25$ kg·m^2.

[8] The spring force is $F(x) = k_0 x + k_1 x^3$, where k_0 is the linear stiffness constant.

[9] Show that $P^T P = I$.

[10] Solve the given equation subject to the initial conditions.

[11] Calculate mode shapes and natural frequencies for Problem 6.14!

[12] The lumped-mass single-degree of freedom system has only one eigenfrequency.

[13] Assume a clamped-free bar.