Dynamics 4

Learning Module 3

Dynamic stability



THE UNIVERSITY *of* EDINBURGH
School of Engineering

DYNAMICS 4

LM3 GUIDE 26 27

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Learning Module 3 | Dynamic stability

Estimated time: 10 hours Complete module before: 20 October

1 Start by reading the Course Notes: For this module you should read **Section 2.4.** Take hand-written notes as you read.

2 Attend the lectures and tutorial sessions and, if you need, watch the lecture recordings later. This will help consolidate what you learned. Keep taking notes.

3 Attempt to solve **Questions 3.1 to 3.5** in **Exercise Sheet 3**. Compare your solutions to the numerical solutions provided at the end of each question. Write down any questions you might have.

4 Compare your solutions to the worked-out example solutions to **Questions 3.1 to 3.5**. Discuss any questions you might have in the tutorial sessions. Arrange to meet with your lecturer if you need further clarifications.

5 Be active in the Learn discussion board thread for this Learning Module, which is labeled **dynamic_stability**. You can post your own questions and help clarify or answer the questions of others.

6 You should also read **Section 2.6** of the Course Notes with examples of real life applications.



In this module

Generalised form of Lagrange's equations
Dynamic stability and instability
Ranges and conditions for dynamic instability

Learning outcomes

Derive equations of motion for dynamic systems from energy-based approaches (e.g. Lagrange's method)

Recognise forms of advanced dynamic behaviour, such as system instability, and appreciate their effects on the dynamic response of structures

This is a study and learning guide to Learning Module 4. You can find the corresponding lecture recordings and slides on Learn. This module has a dedicated thread in the discussion board on Learn.

Please note that the course time and the recommended *before dates*, are estimated and may differ from person to person. You should not see these as targets but instead as a way to help you plan your semester and the preparation for exams. The estimated time includes going through all the course materials, interaction in the discussion boards and self-study time.

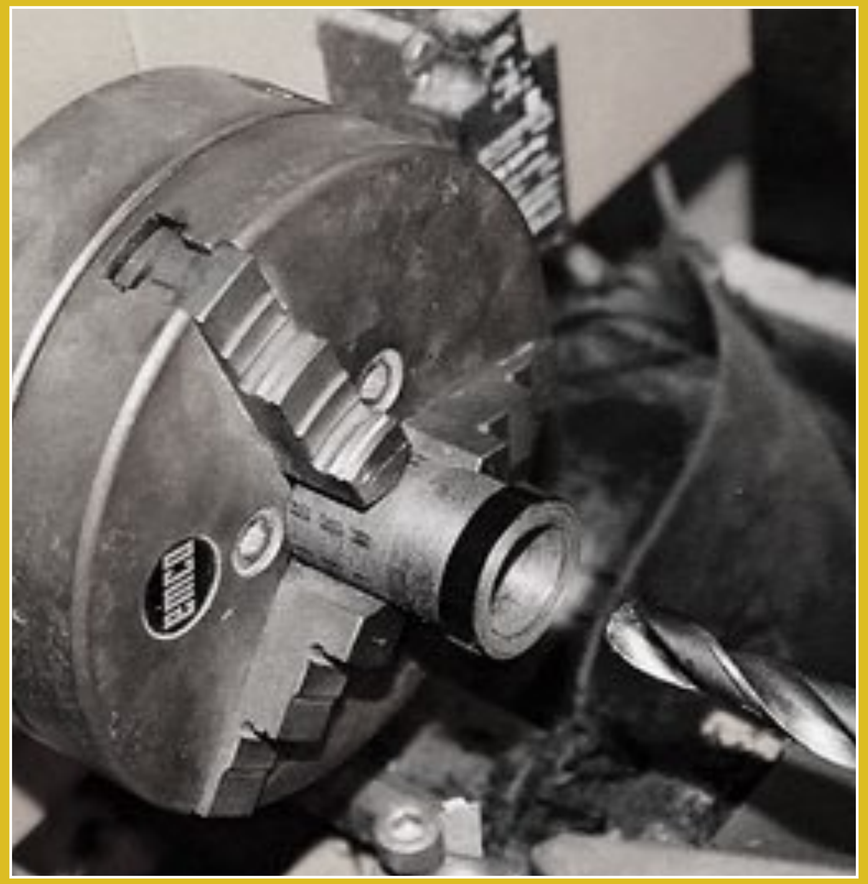
Dynamic stability

- Undesirable response under steady-operating conditions (without any external dynamic excitation)
- Examples:
  - Brake squeal
  - Machine tool chatter
  - Wobbly bridge
  - Galloping of power lines
  - Flutter instabilities (bridges, aircraft wings, etc.)
  - ...



Disk brake squeal

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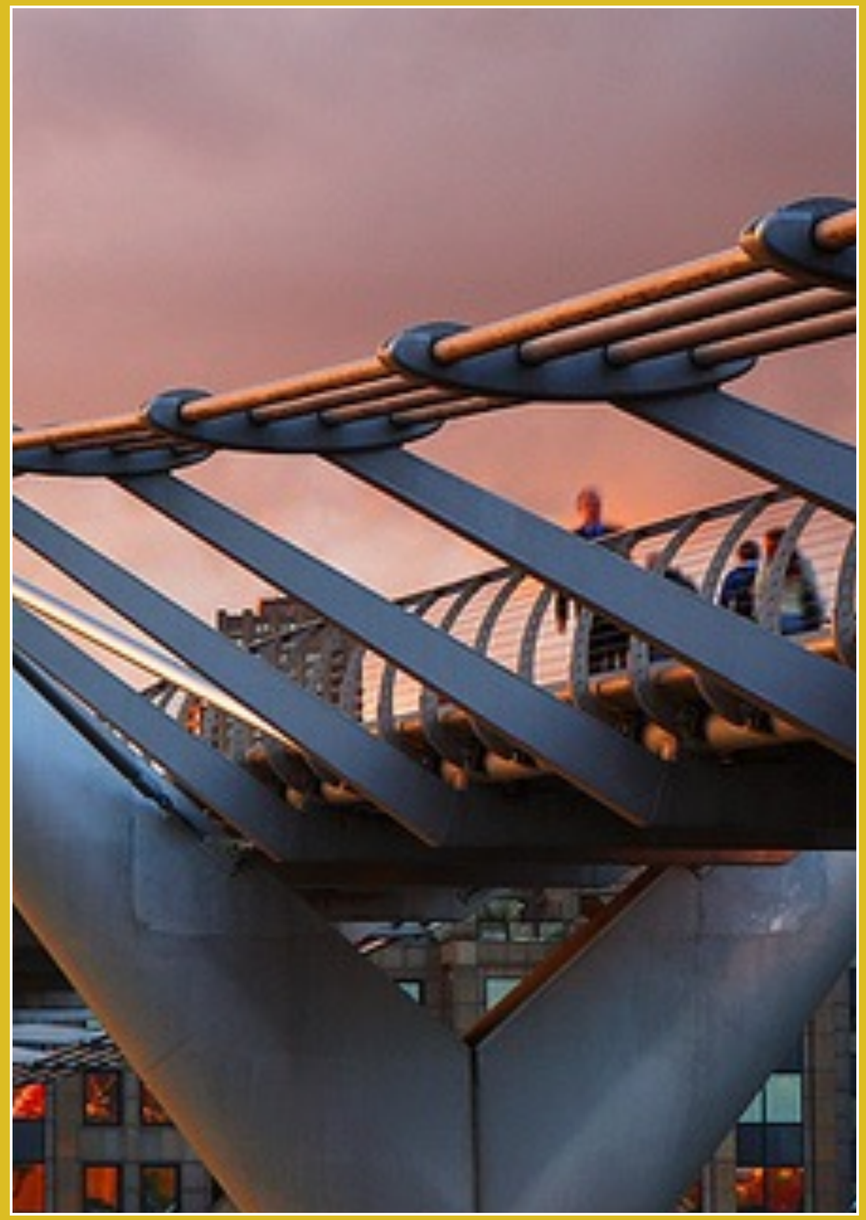


Conventional lathe
Machine tool chatter

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The Millennium Bridge, London
Wobbly bridge

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Galloping overhead power lines

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NASA X-29 research aircraft
Flutter instabilities, aircraft wings

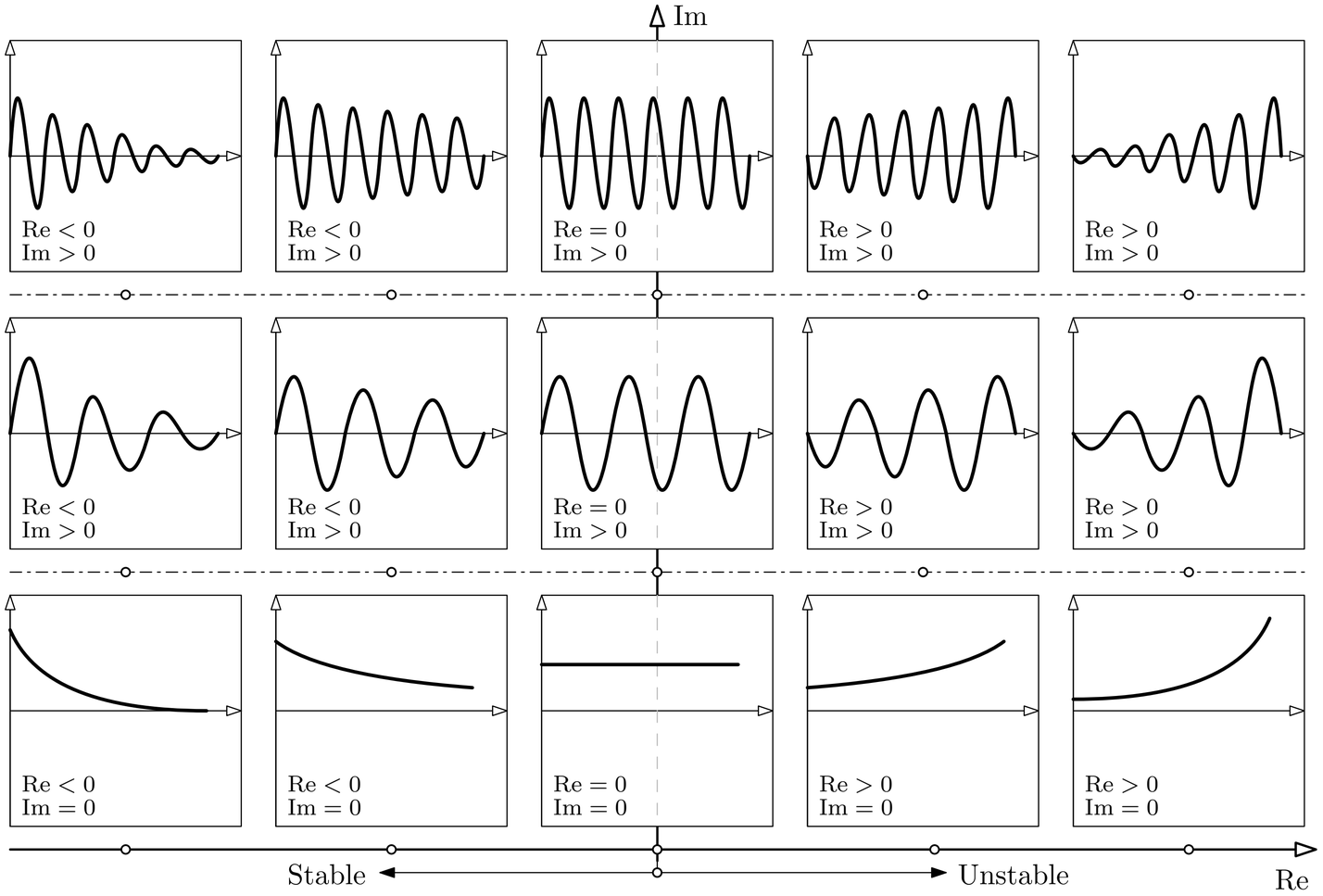
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Main propeller of the USS Churchill
Flutter instabilities

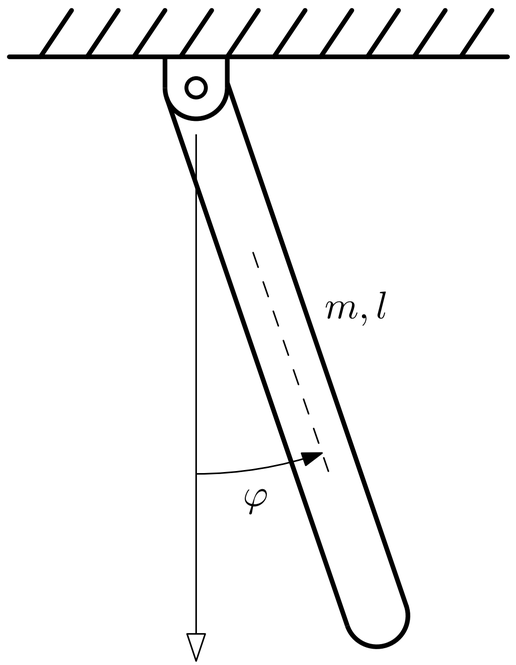
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Steps to analyse dynamic stability



Example (CN)

Define a system variable, obtain the equations of motion for this variable and analyse the stability of the bar shown in its two steady state configurations. Start by identifying these configurations.



Example (CN)

Define a system variable describing the dynamics of the pendulum shown, obtain the EoM, find steady state solutions and analyse stability as a function of the rotation velocity.

