



Image from FDR Library and Museum

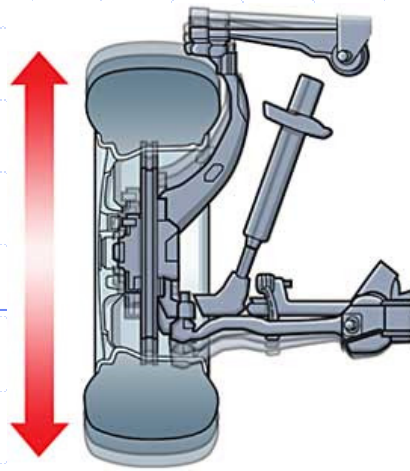


Image from Hunter Engineering Co.

MAE 340 – Vibrations

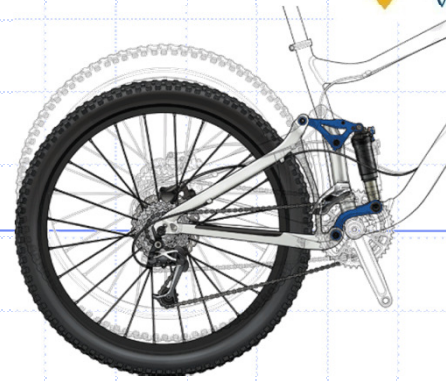


Image from Giant Bicycle Inc.



Image from dub-connection

# Introduction to Mechanical Vibrations

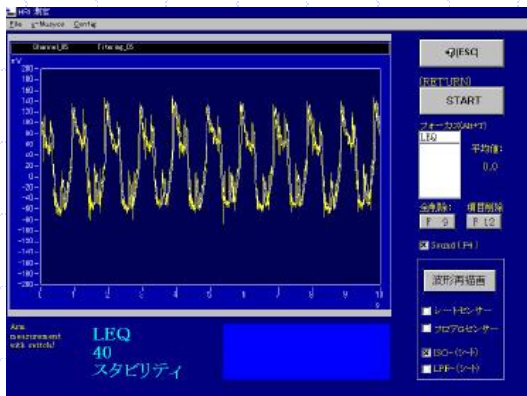


Image from A-Tech Instruments Ltd.

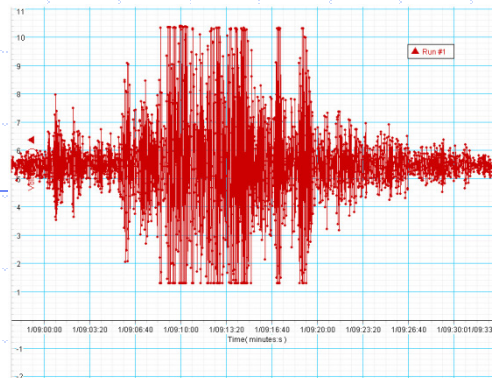


Image from Sound by Singer

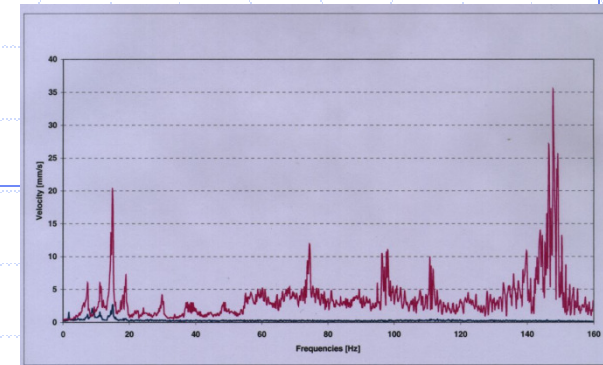


Image from E. Klingelé

# Vibration

- Vibration is the study of:  
the repetitive motion of objects relative to a stationary frame of reference or nominal position (e.g., the equilibrium position)
- Vibration is an important factor in many designs:
  - Products that break if they vibrate too much:
    - ◆ Buildings and bridges
    - ◆
    - ◆

# Vibration

- Products that can't be used if they vibrate too much:
  - ◆ Power/machine tools
  - ◆ Robots
  - ◆
- Products that customers don't like to vibrate too much:
  - ◆ Seat for automobile/tractor/airplane
  - ◆
- Products that have to vibrate in a specific way:
  - ◆
  - ◆
  - ◆

# Free vs. Forced Vibration

- Free Vibration vs. Forced Vibration

- Free Vibration

- All **interfaces** of the body with the environment **are static**.

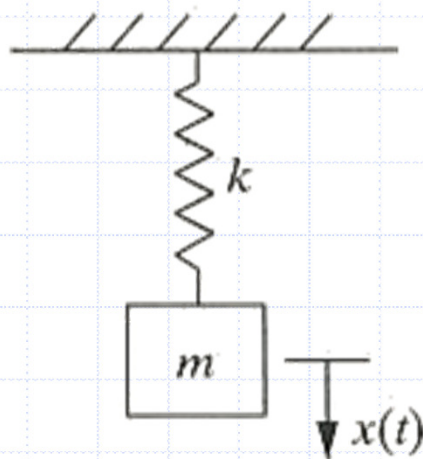
- Forced Vibration

- At least one point of the **body** is **subjected to periodic forces** or displacements.

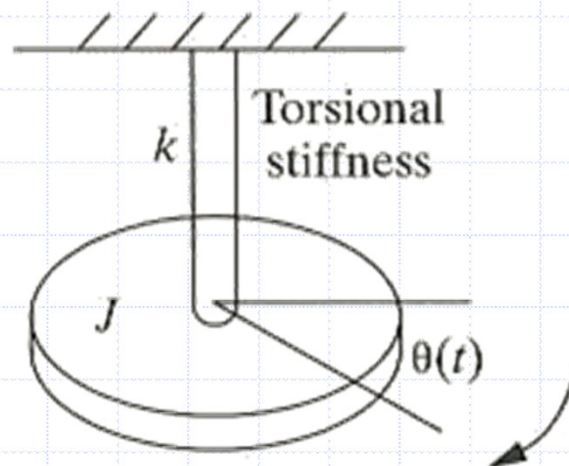
# SDOF vs. MDOF Systems

- In a Single-Degree-of-Freedom (**SDOF**) System we study the motion of a rigid body in **one direction**.

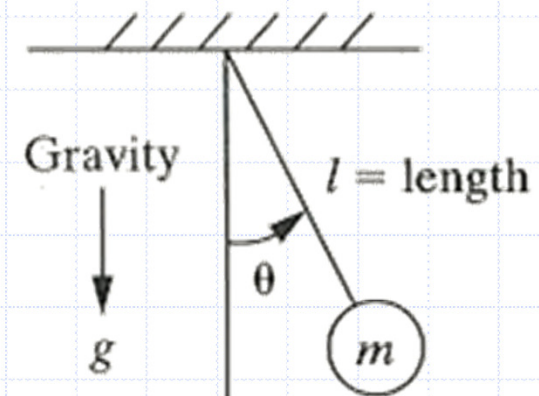
The motion may be **rectilinear** or **rotational**.



Spring-mass  
 $m\ddot{x} + kx = 0$



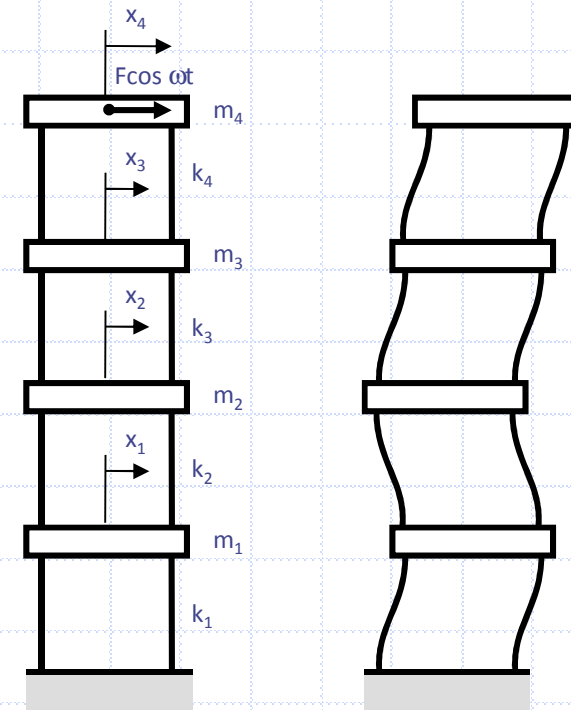
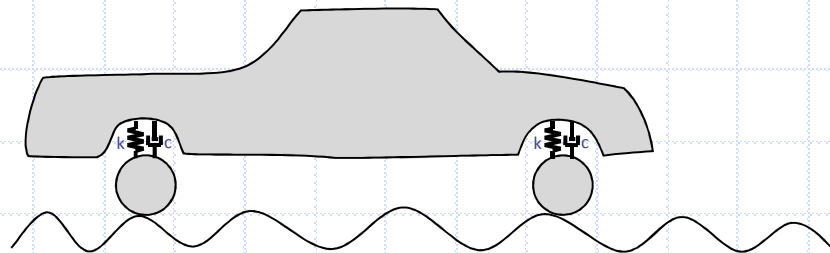
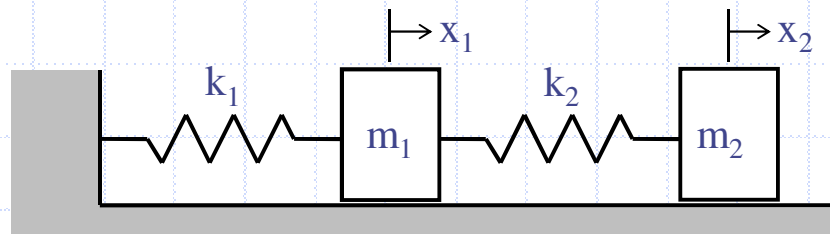
Shaft and disk  
 $J\ddot{\theta} + k\theta = 0$



Simple pendulum  
 $\ddot{\theta} + (g/l)\theta = 0$

# SDOF vs. MDOF Systems

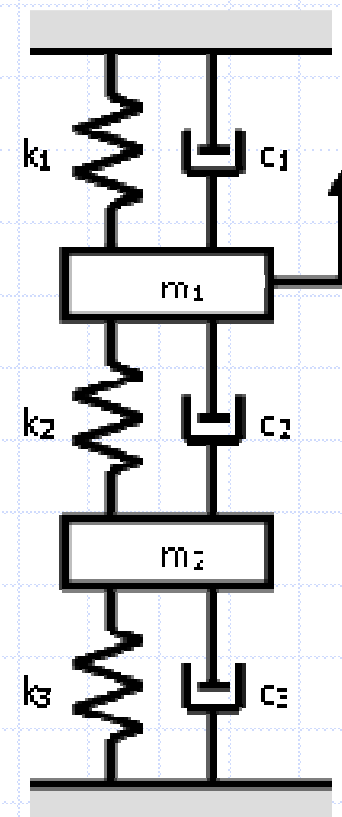
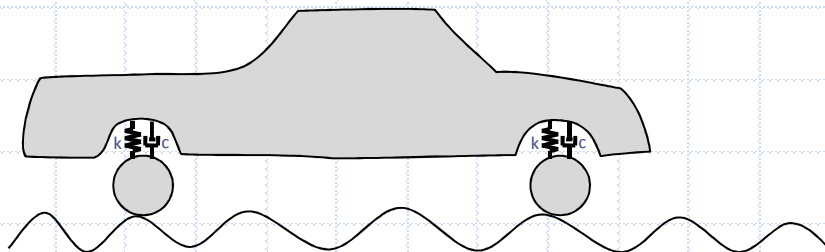
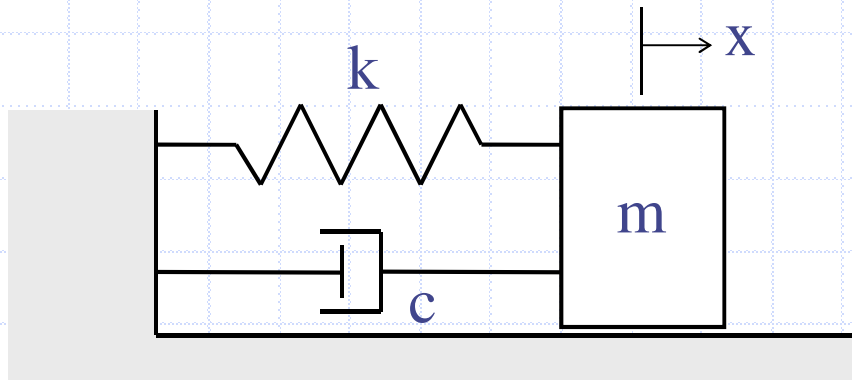
- In a Multi-Degree-of-Freedom (**MDOF**) System we study the independent motions of **multiple rigid bodies** or one rigid body in **multiple directions**.





# Discrete vs. Continuous Systems

- A **discrete system** has rigid (lumped) masses connected by massless, flexible members (e.g., massless springs and dampers)



# Discrete vs. Continuous Systems

- A **continuous system** has flexible members whose distributed mass is significant to the vibrations

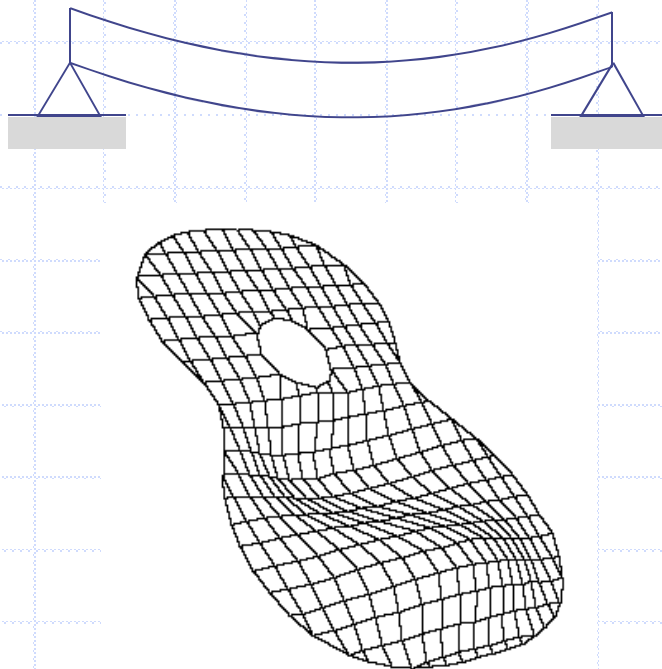


Image from [www.jeffkemp.com](http://www.jeffkemp.com)

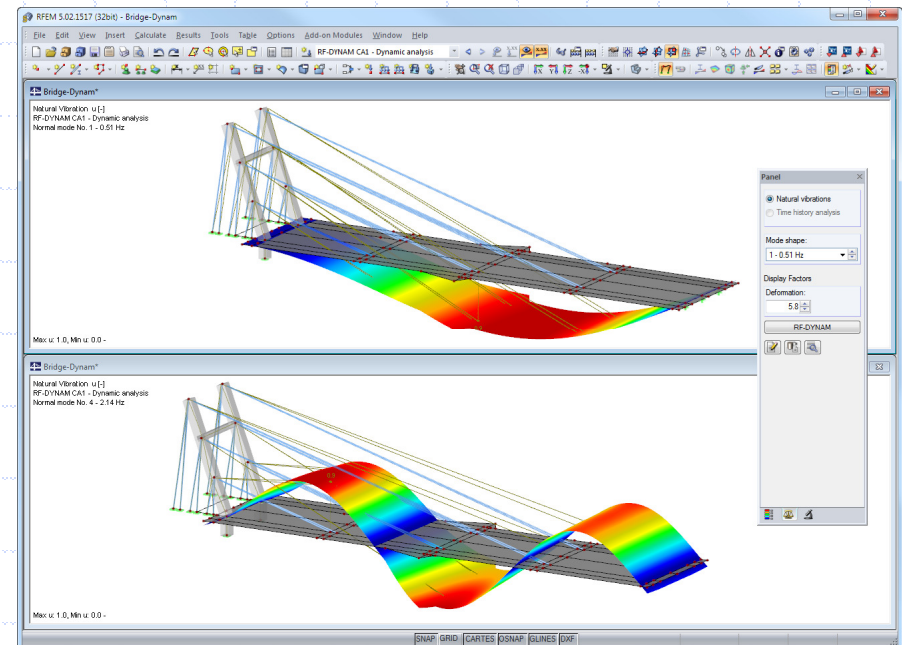


Image from Dlubal Software GmbH



# Spring-Mass System



# Spring-Mass System

- Solving differential equation

# Spring-Mass System

- How do we find  $A$  and  $\phi$ ?

# Graphing $x(t)$



# Working with Vibration Amplitudes

- If we have any two of:
  - Natural frequency =
  - Displacement amplitude =
  - Velocity amplitude =
  - Acceleration amplitude =

then we can get the other two.

# Vibration Nomograph

- Use it to specify limits on vibration:

- Frequency
- Displacement amplitude
- Velocity amplitude
- Acceleration amplitude

