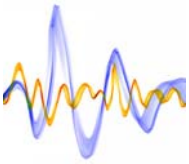

Vibrations and Acoustics

1. Vibrations : Introduction

Arnaud Deraemaeker (aderaema@ulb.ac.be)

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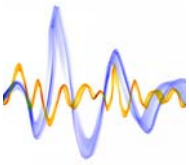


Definition and mechanism of vibrations

2

Vibrations : definition

Vibration refers to mechanical oscillations about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. (from wikipedia)

pendulum

Mass on a spring

3

Vibrations are all around us

Vibrator in cell phone

Tools

Rotating machines

Sound

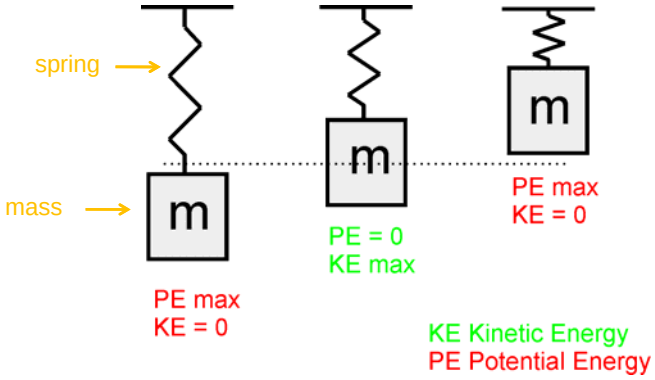
Shaver

Tram

4

Mechanism of vibrations

Transfer between kinetic energy and potential energy



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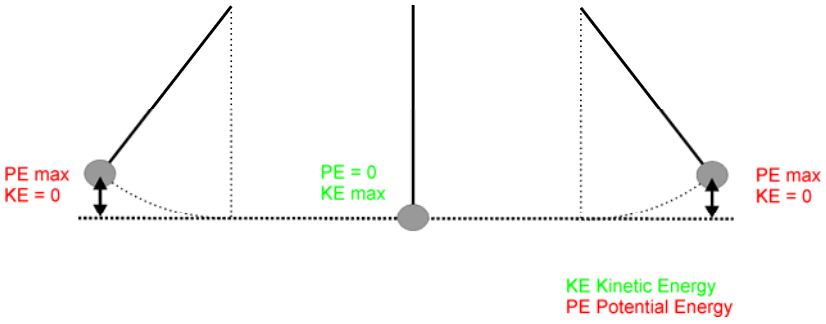
Mechanism of vibrations

Transfer between kinetic energy and potential energy



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Sources of excitation

Free vibrations

Short initial excitation

Forced Vibrations

Continuous excitation

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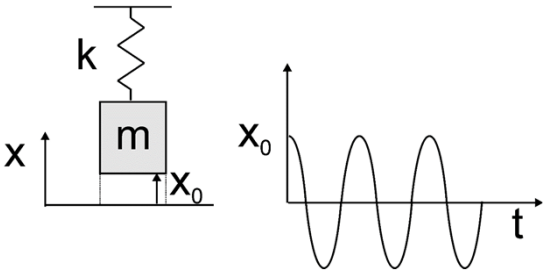
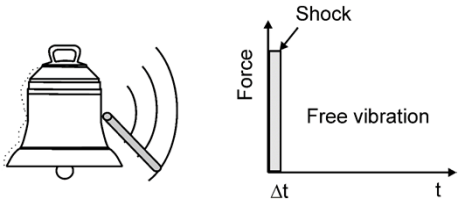
Free vibrations

Initial displacement



Shock



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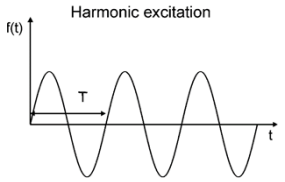
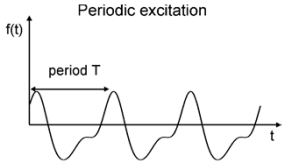
Forced vibrations : types of input forces

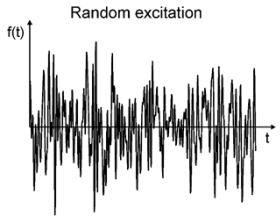
Harmonic force signal



Periodic force signal



Random force signal



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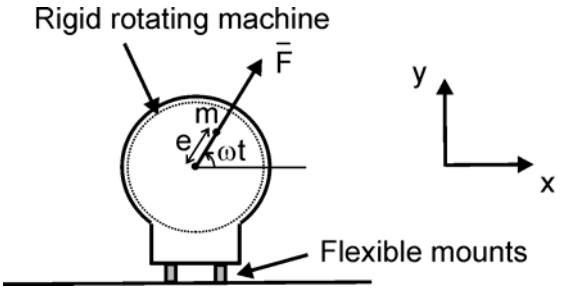
Harmonic excitation

The signal is in the form of a sine or/and cosine function



$$F_x = me\,\omega^2 \cos(\omega t)$$
$$F_y = me\,\omega^2 \sin(\omega t)$$

Mobile phone vibrator

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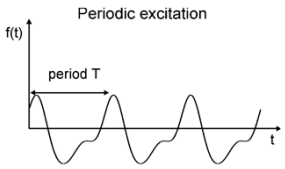
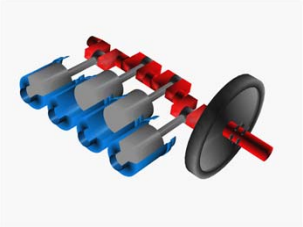
Periodic excitation

The signal repeats itself



Power generator



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Random excitation

No structure in the signal

- Wind
- Tire on a road
- Waves
- Earthquakes

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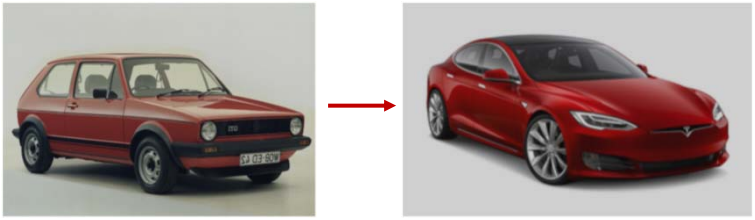
Vibrations in mechanical engineering structures

-Vibration sources are increasing
-Comfort demands are increasing
-Health issues are appearing
-In some cases, high precision technologies require very low vibration levels
-New designs make some structures more susceptible to vibrations



Reduction of weigth for optimal use of material results in higher levels of vibrations

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Vibrations in structures

A first example : the Millenium bridge in London

Tate modern museum of Art

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Vibrations in structures

Opening june 10, 2000

15

Vibrations in structures

A second example : aeroelastic flutter in aircrafts

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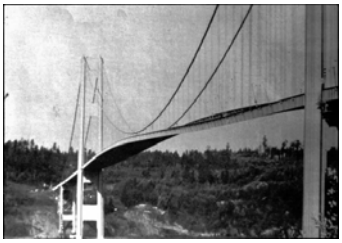
Vibrations in structures

A third (catastrophic) example: Takoma Narrows bridge, USA, 1940



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Vibrations in civil engineering structures

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Undesirable effects of vibrations

Fatigue
Noise
Comfort
Health
Performances
…
(collapse)

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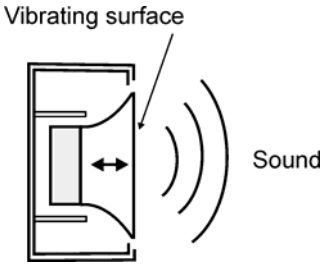
Positive effects of vibrations

- High frequency vibrations to decrease friction in engines (formula 1)
- Electric tooth brush, sander
- Musical instrument
- Loudspeaker



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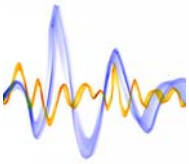
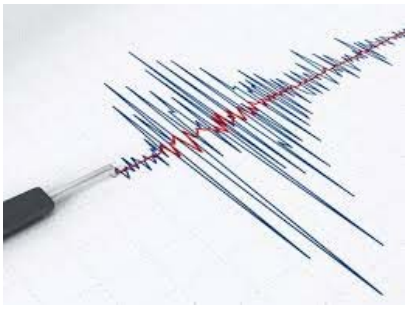


Case studies



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A test-case based learning of vibrations in mechanical engineering

Case study 1 : Payload comfort in space launchers

- Source of excitation
- Effects
- Design methodology
- Remedial measures

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A test-case based learning of vibrations in mechanical engineering

Case study 2 : Passenger comfort in cars (suspension)

- Source of excitation
- Effects
- Design methodology
- Remedial measures

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A test-case based learning of vibrations in mechanical engineering

Case study 3 : Passenger comfort in cars (engine vibration)

- Source of excitation
- Effects
- Design methodology
- Remedial measures

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A test-case based learning of vibrations in mechanical engineering

Case study 4 : Aircraft tail vibration

- Source of excitation
- Effects
- Design methodology
- Remedial measures

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A test-case based learning of vibrations in mechanical engineering

Case study 5 : Fatigue analysis of wind turbines

- Source of excitation
- Effects
- Design methodology
- Remedial measures

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