Title: Research Skills - Lecture 3A

Date: Aug 20, 2010 09:00 AM

URL: http://pirsa.org/10080005

Abstract:

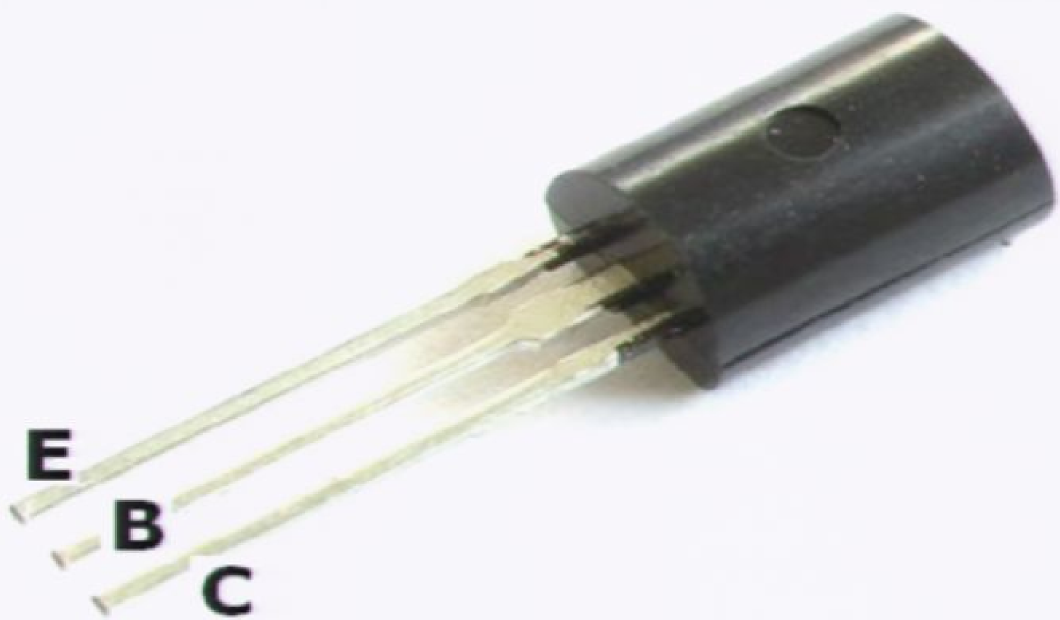
Transistors

Joel Lamy-Poirier

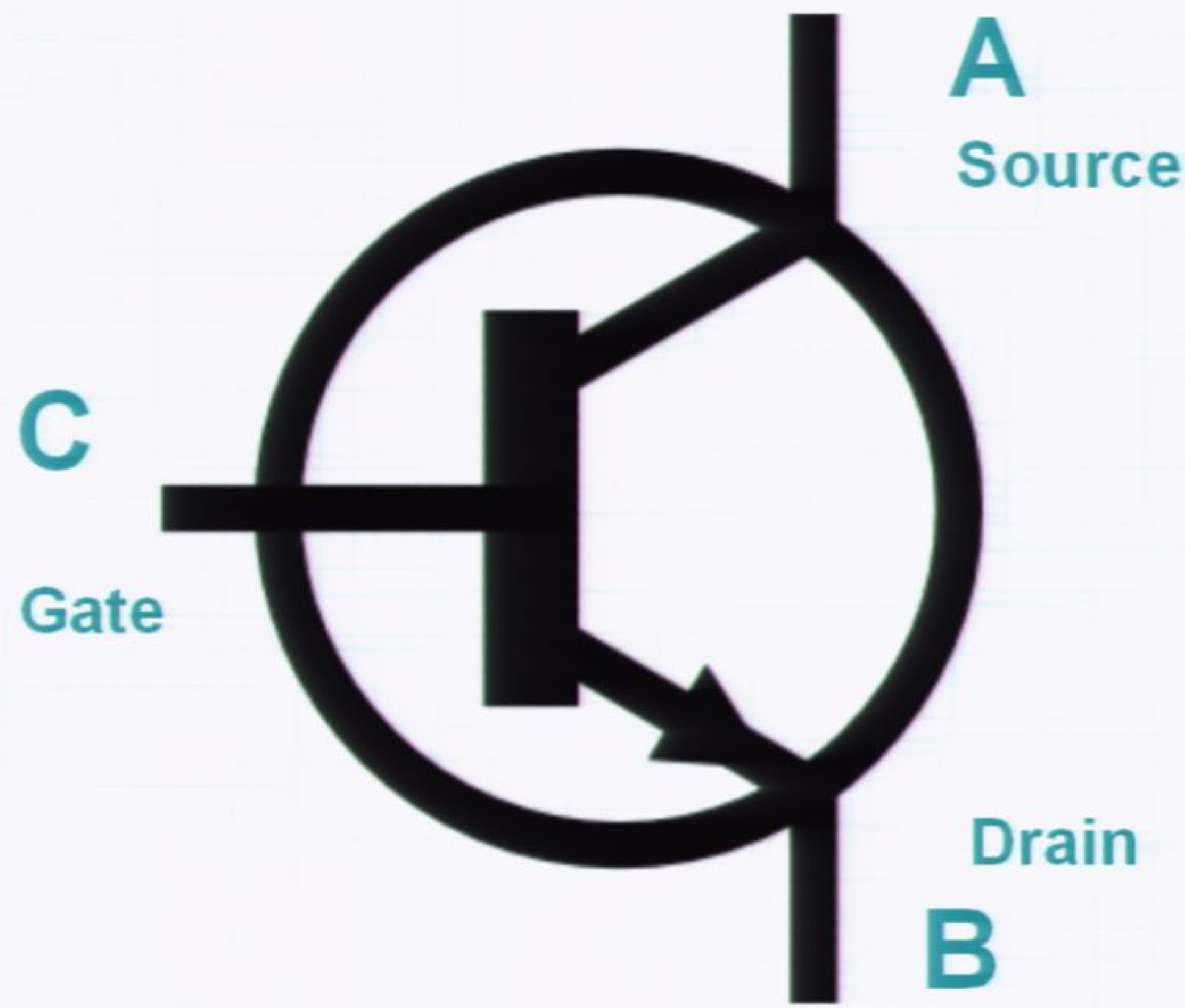

Transistors
Joel Lamy-Poirier

Outline

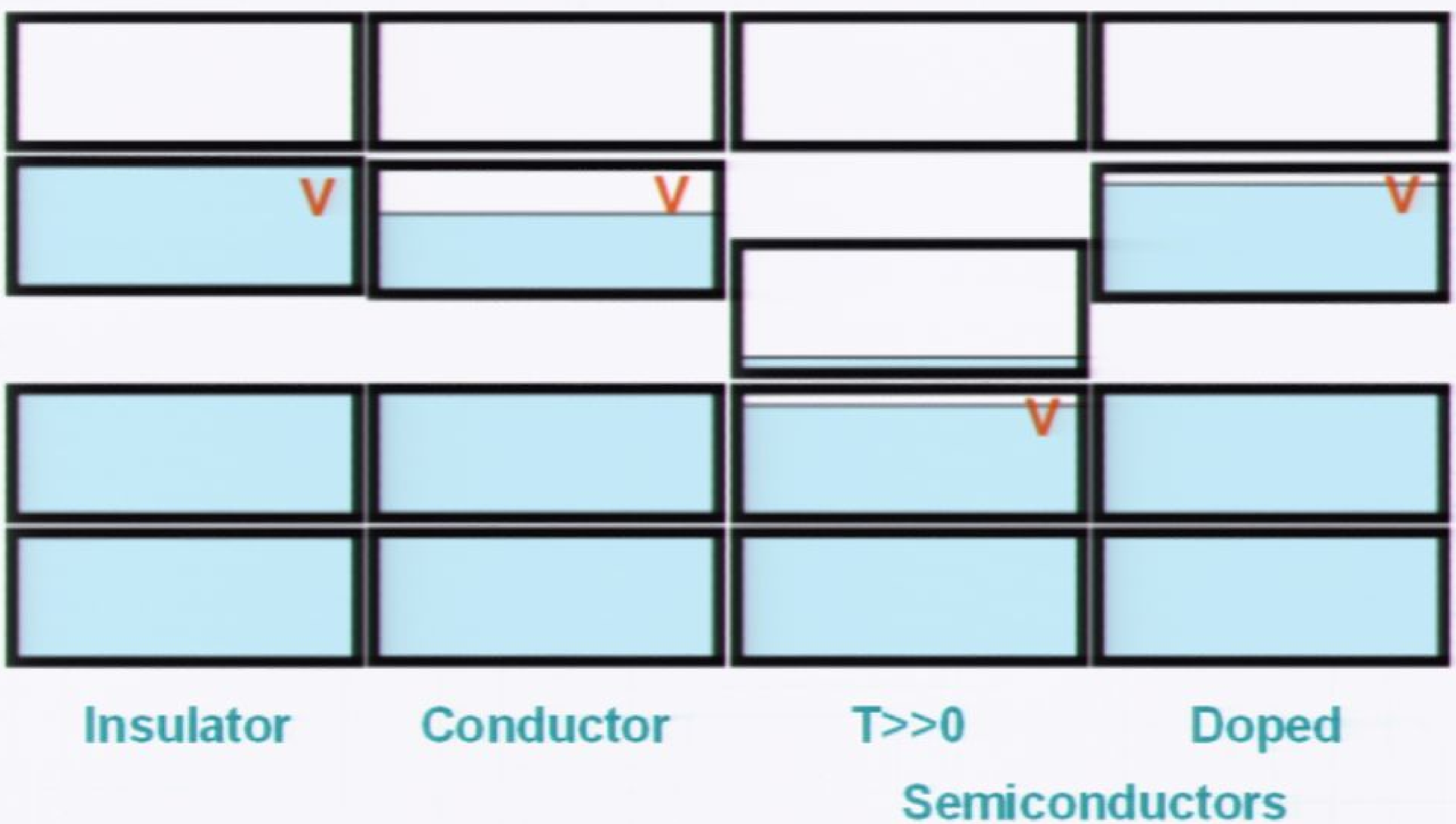
- What is a transistor?
- How does it work?
- What do we use them for?



What is a transistor?



How does it work
Energy bands



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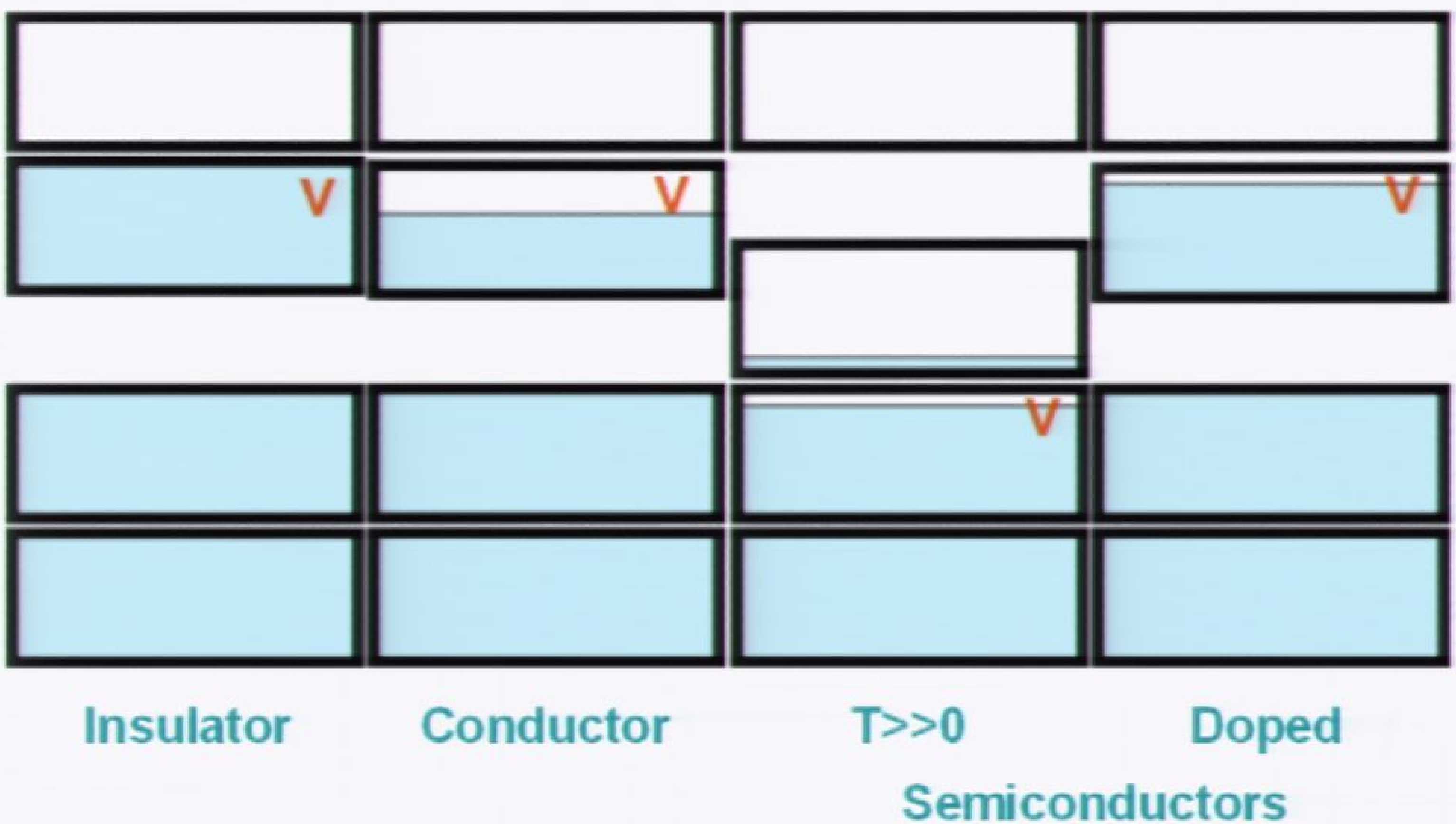

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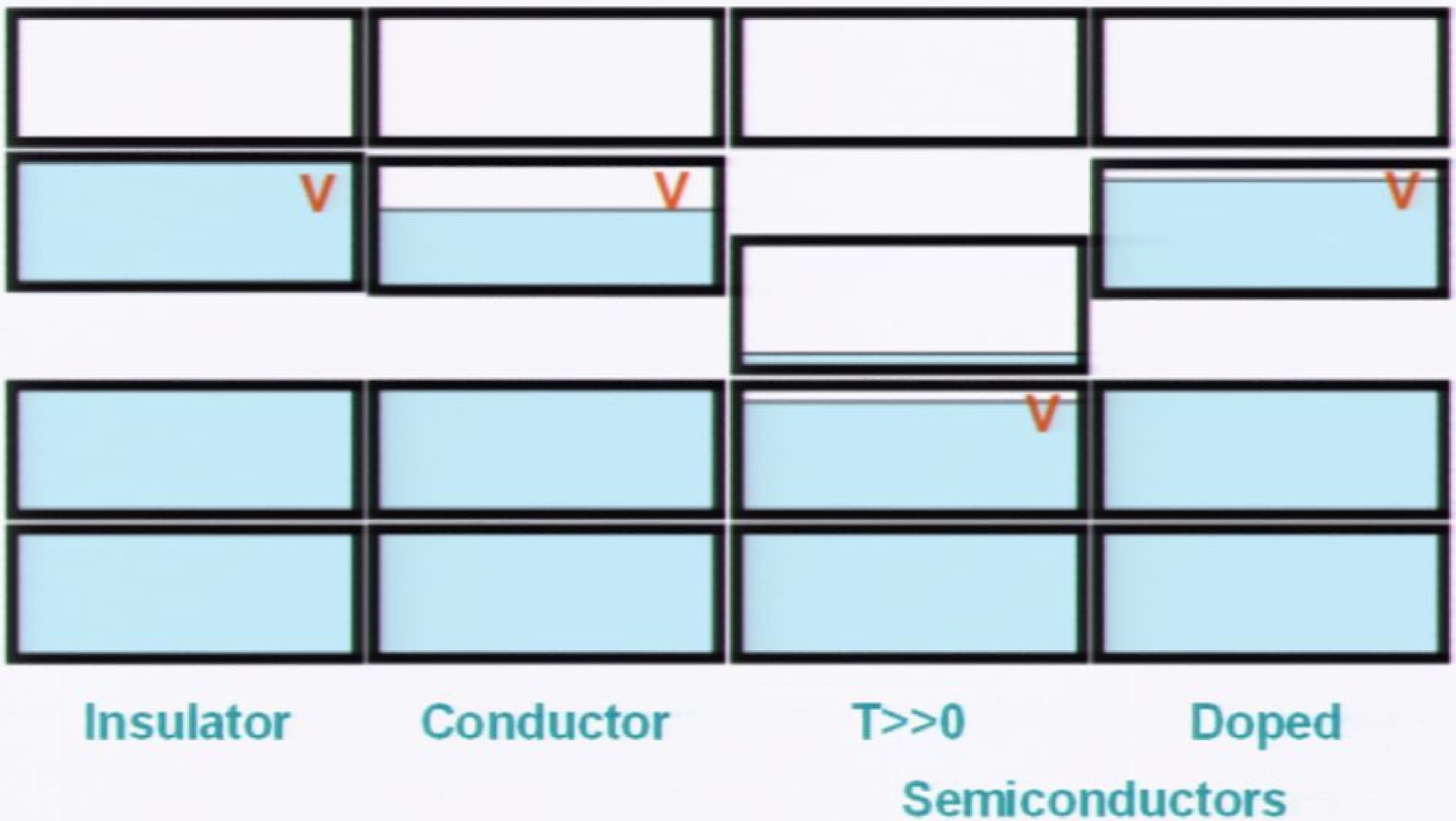

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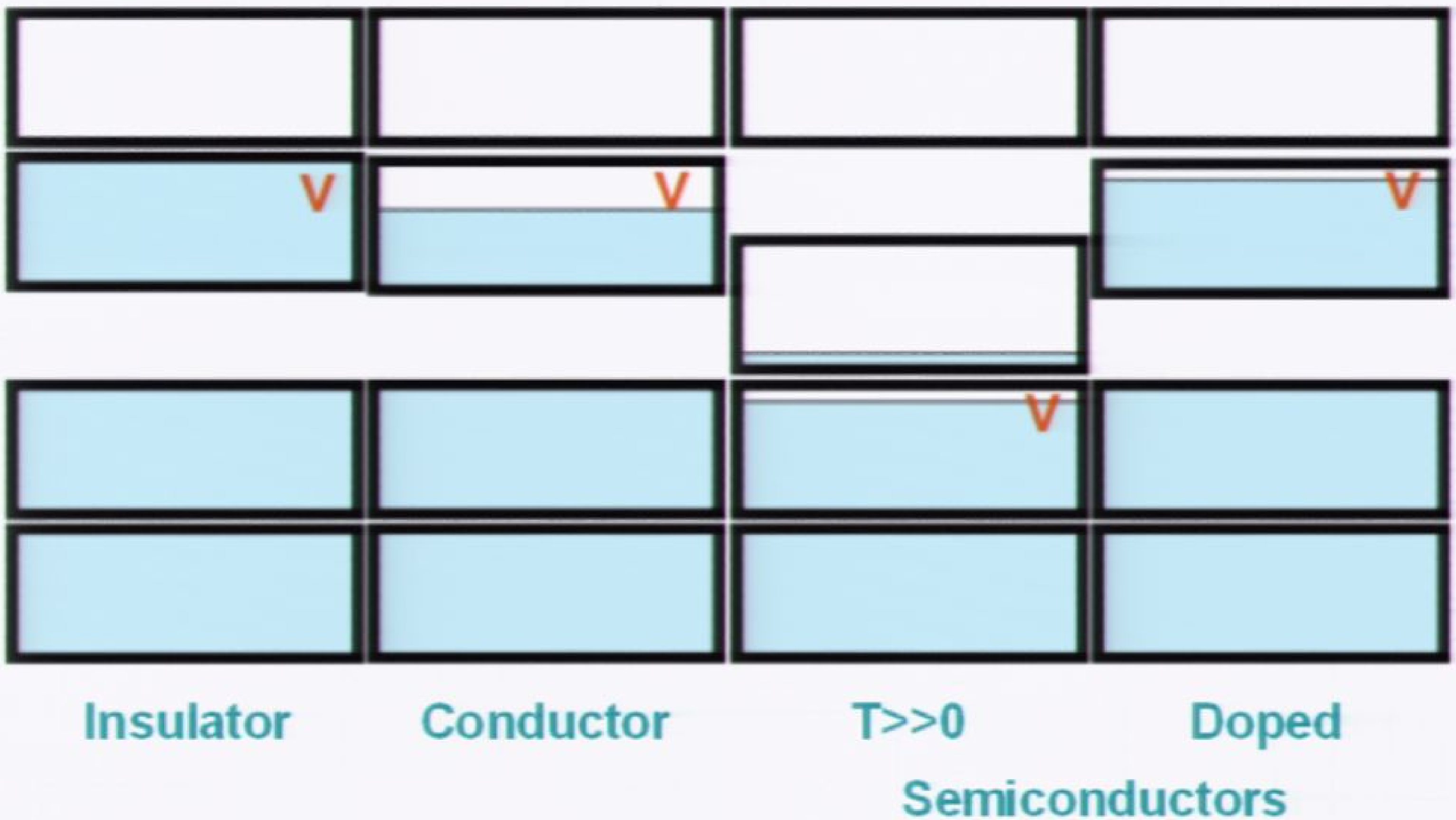

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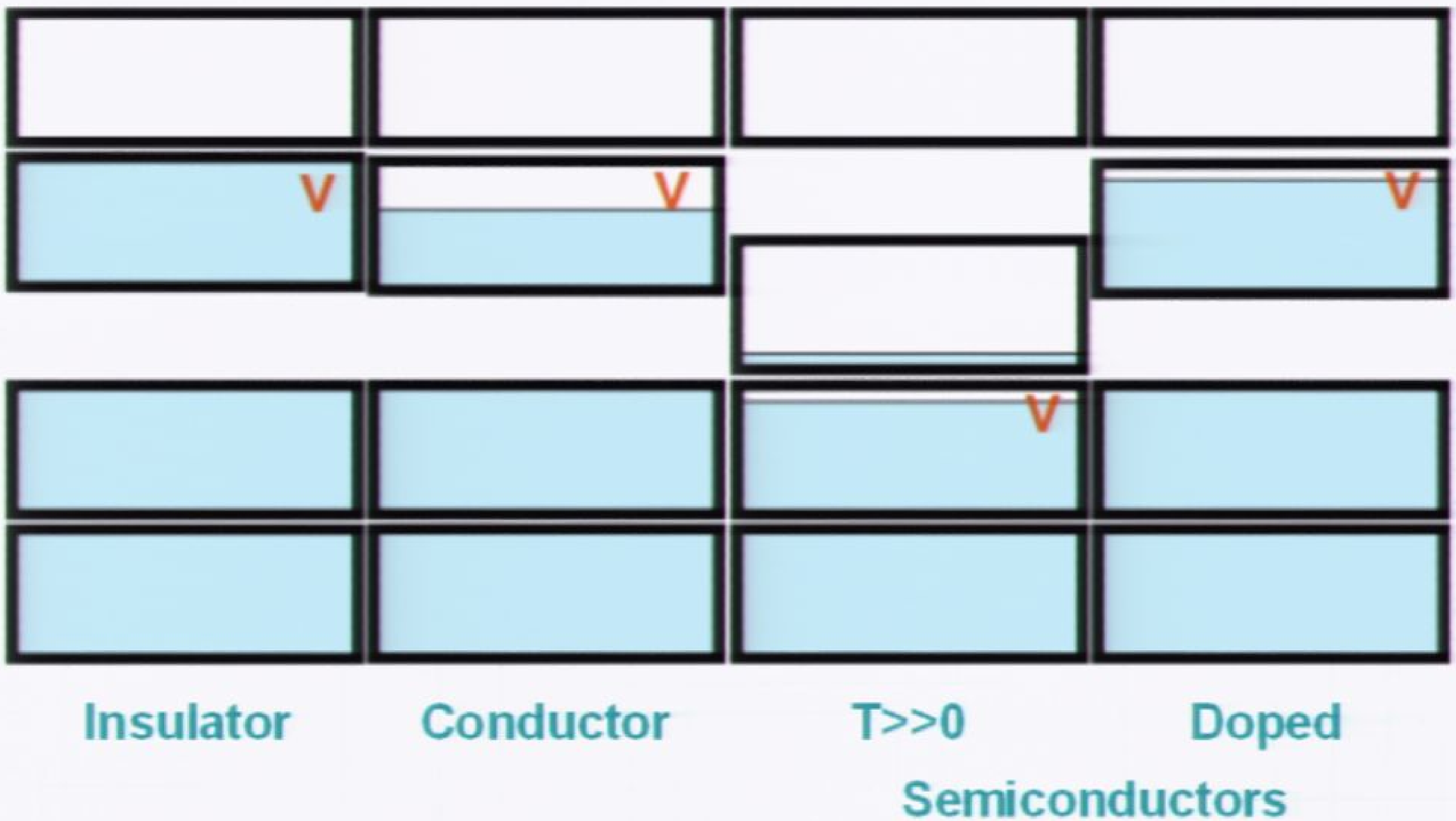

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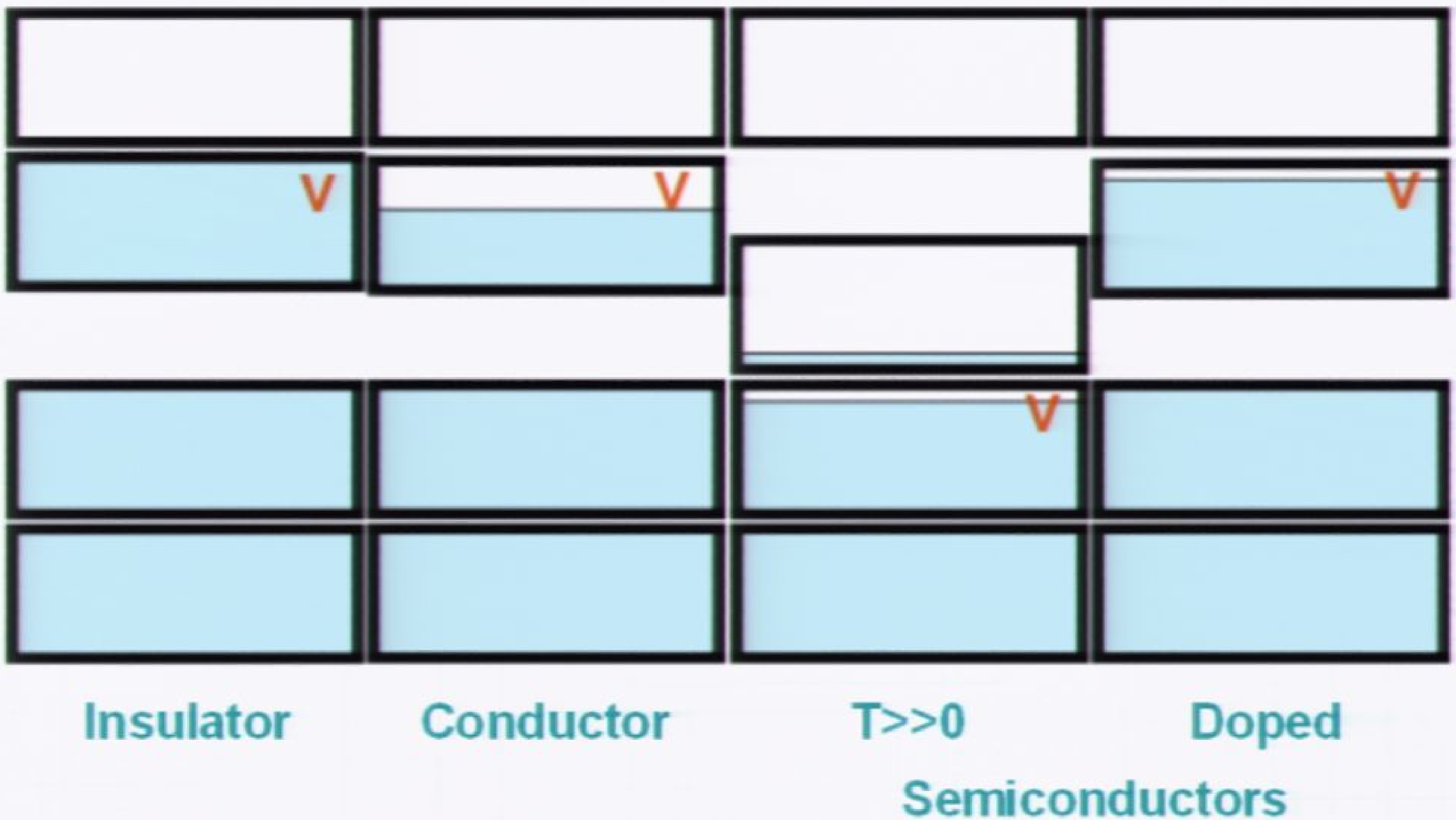

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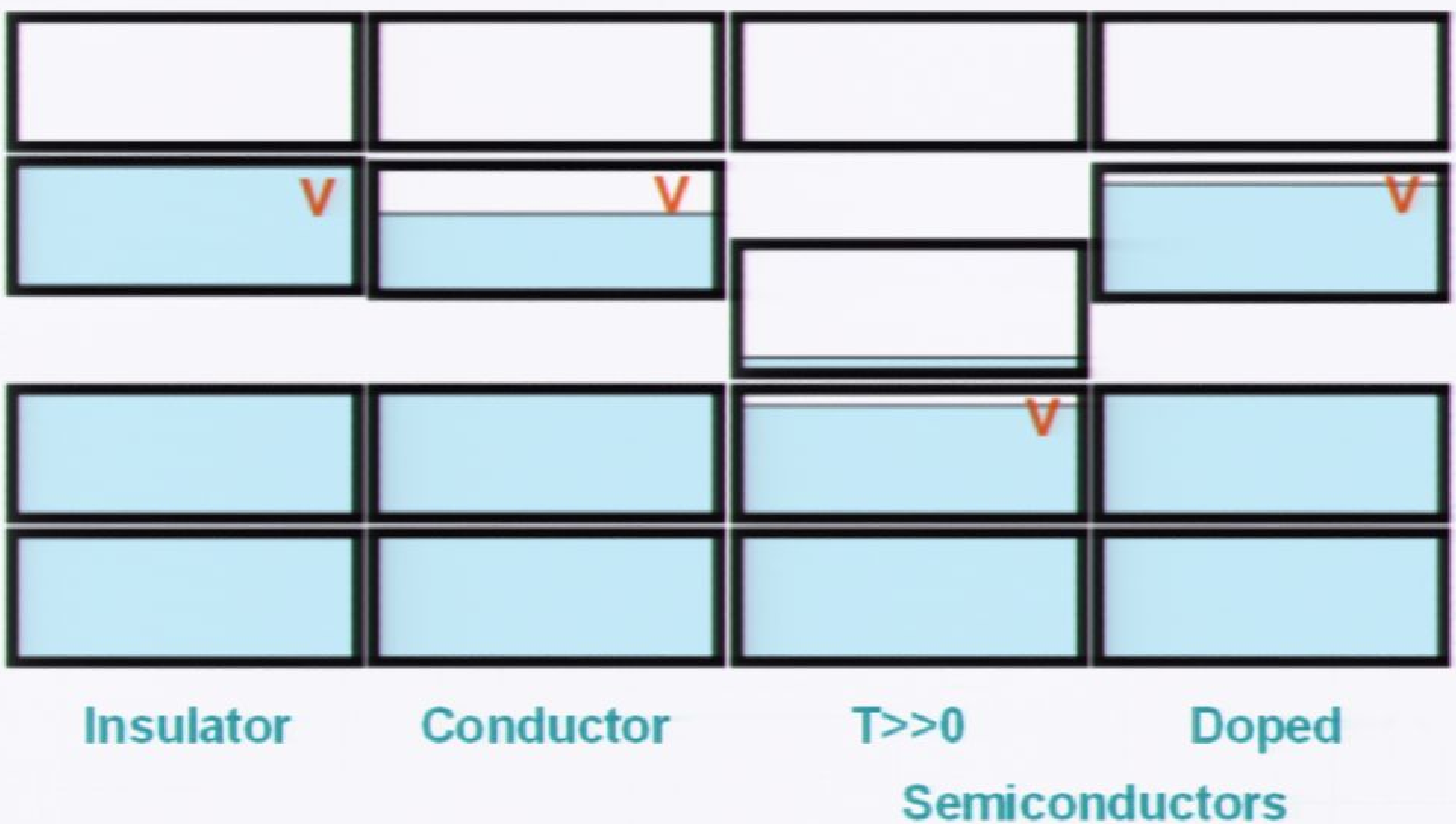

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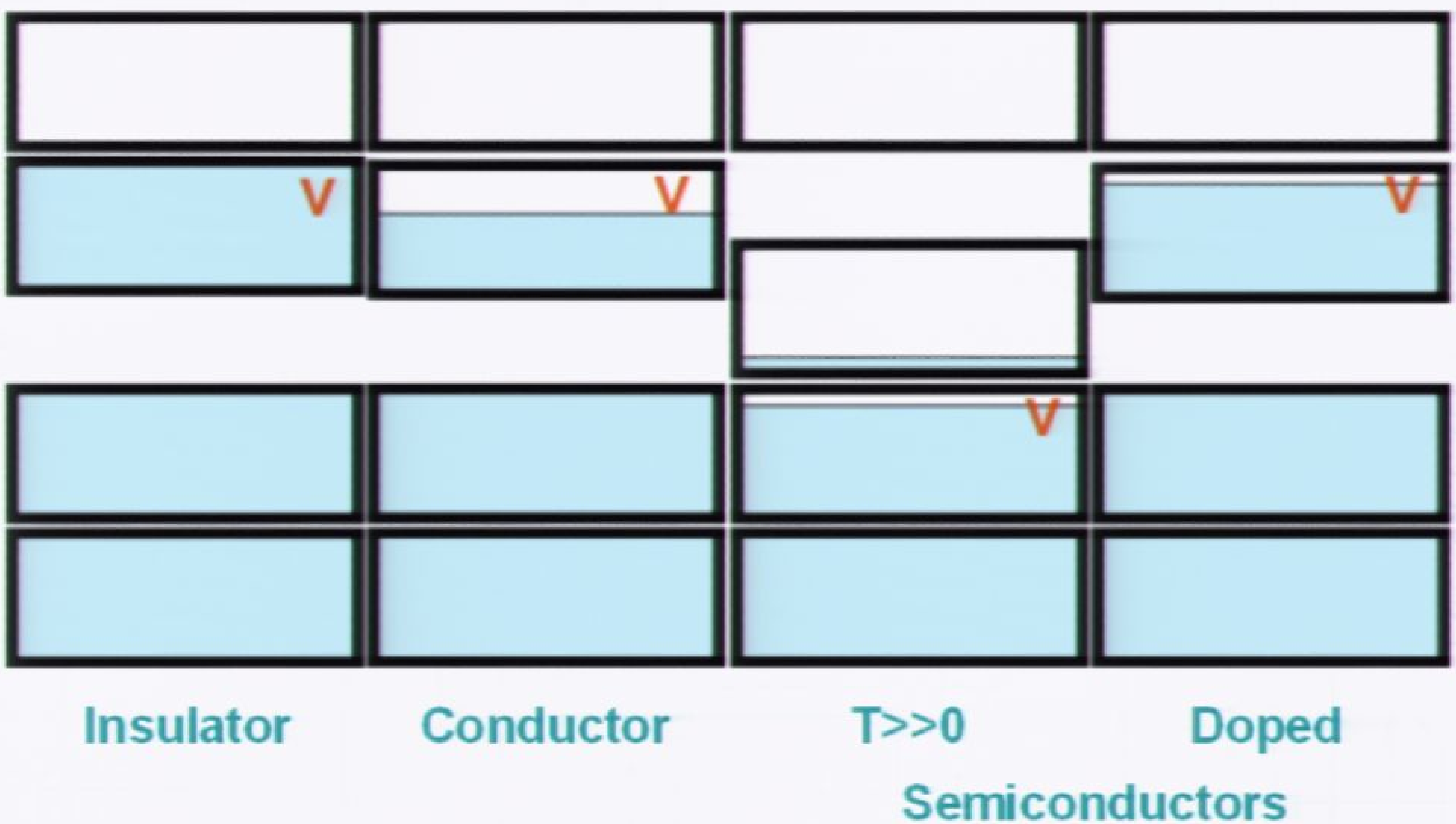

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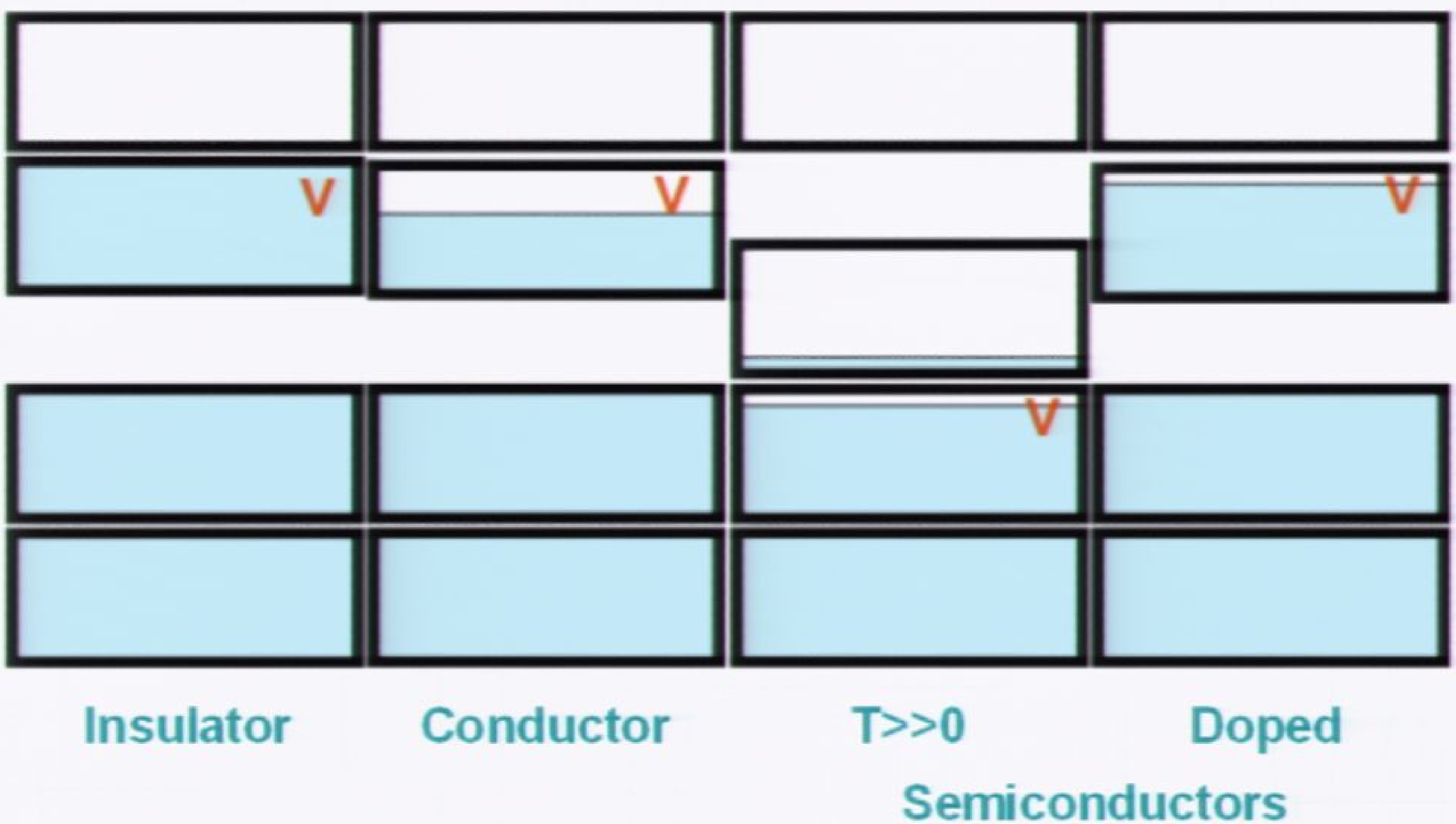
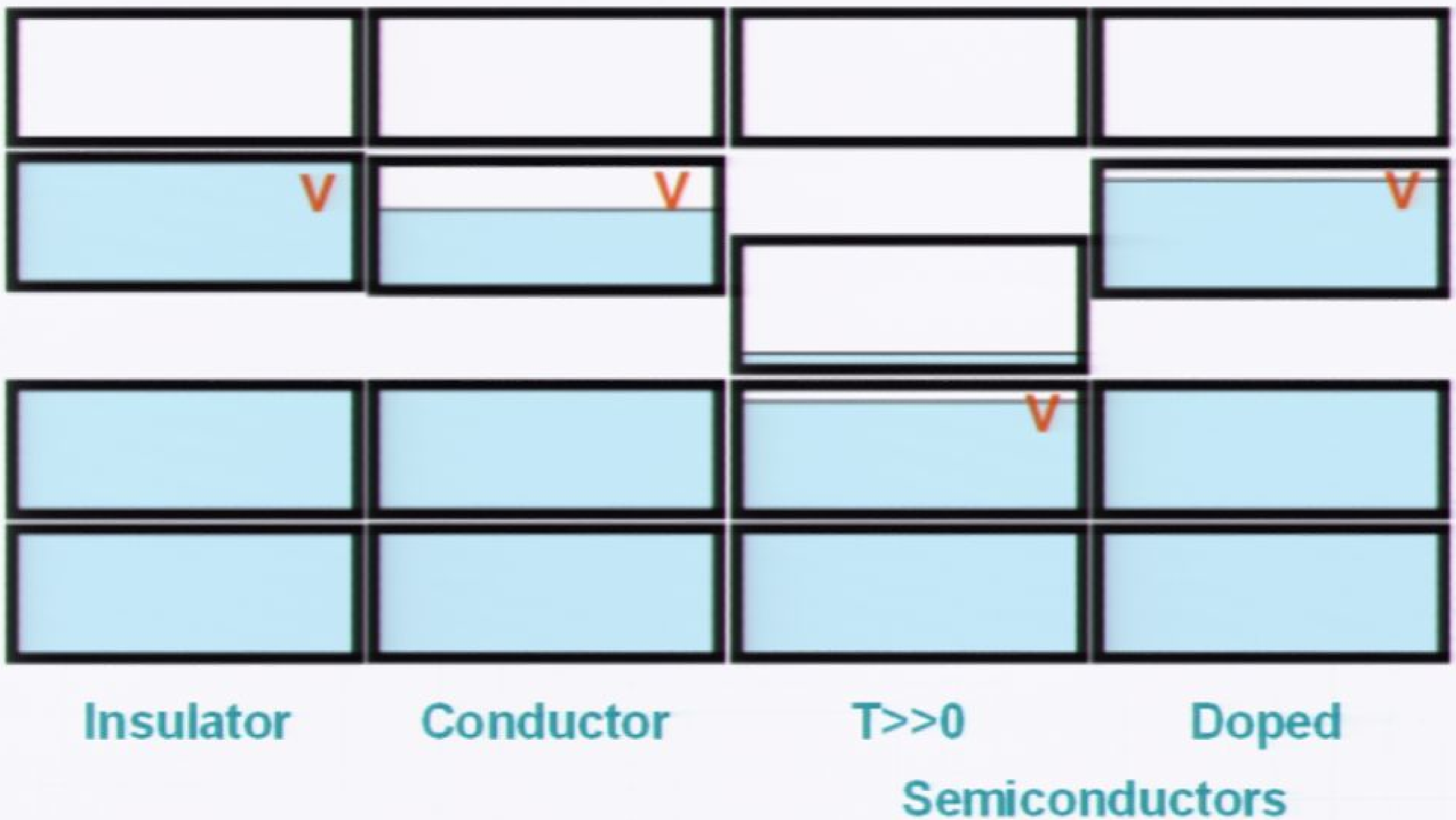


How does it work
Energy bands

Insulator Conductor T>>0 Doped

Semiconductors

How does it work
Energy bands



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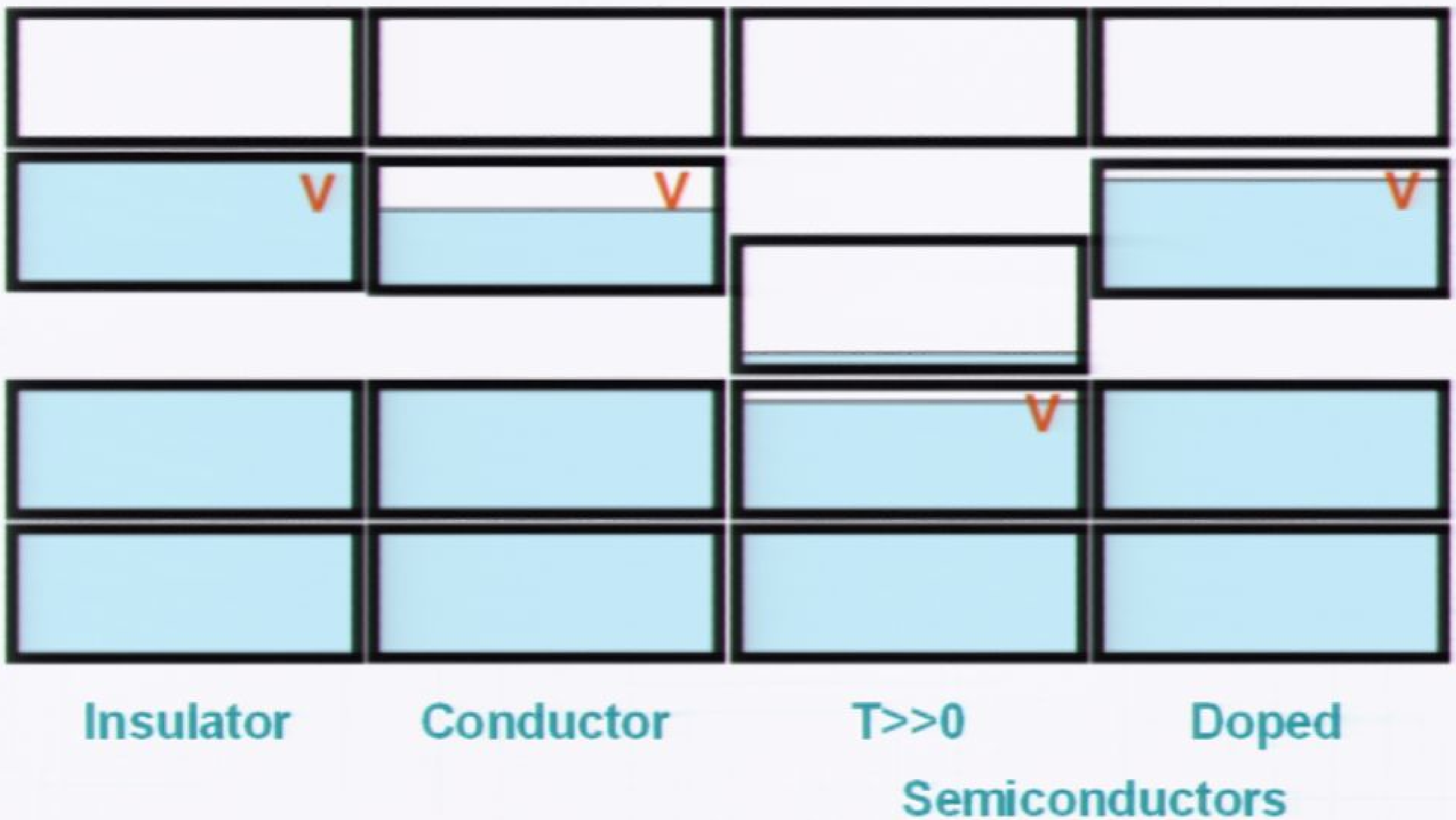

How does it work
Energy bands

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How does it work
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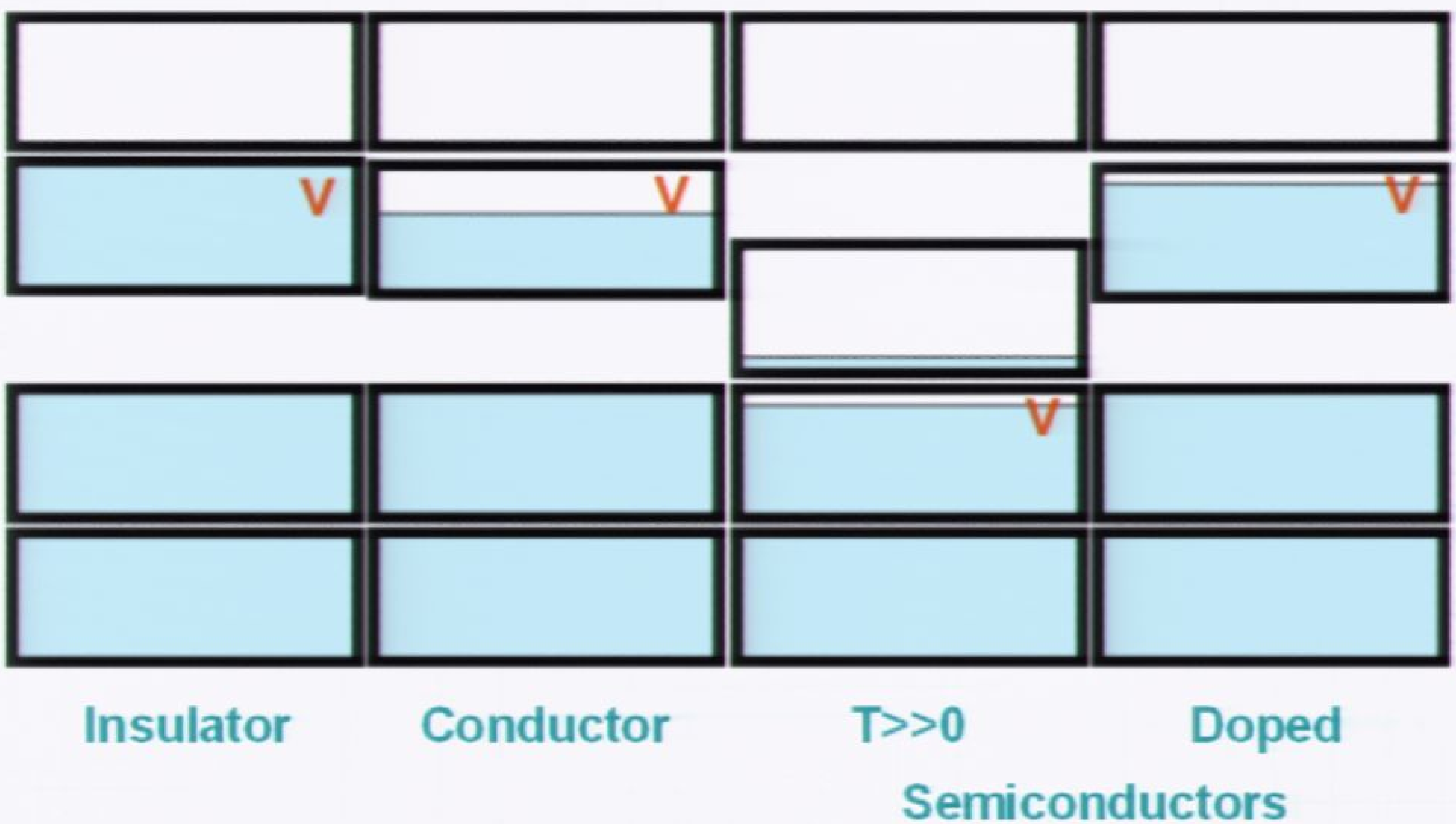

How does it work
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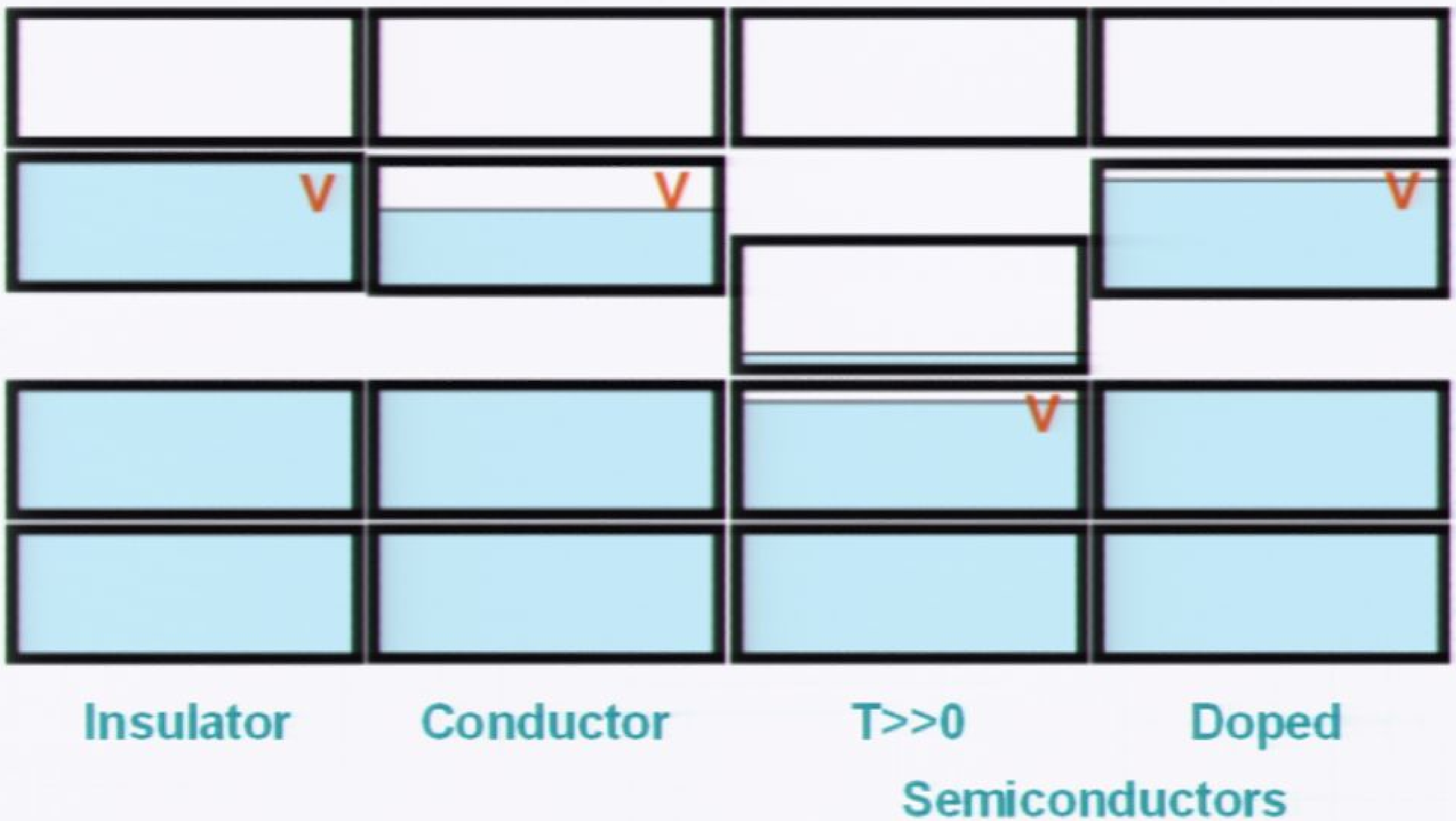

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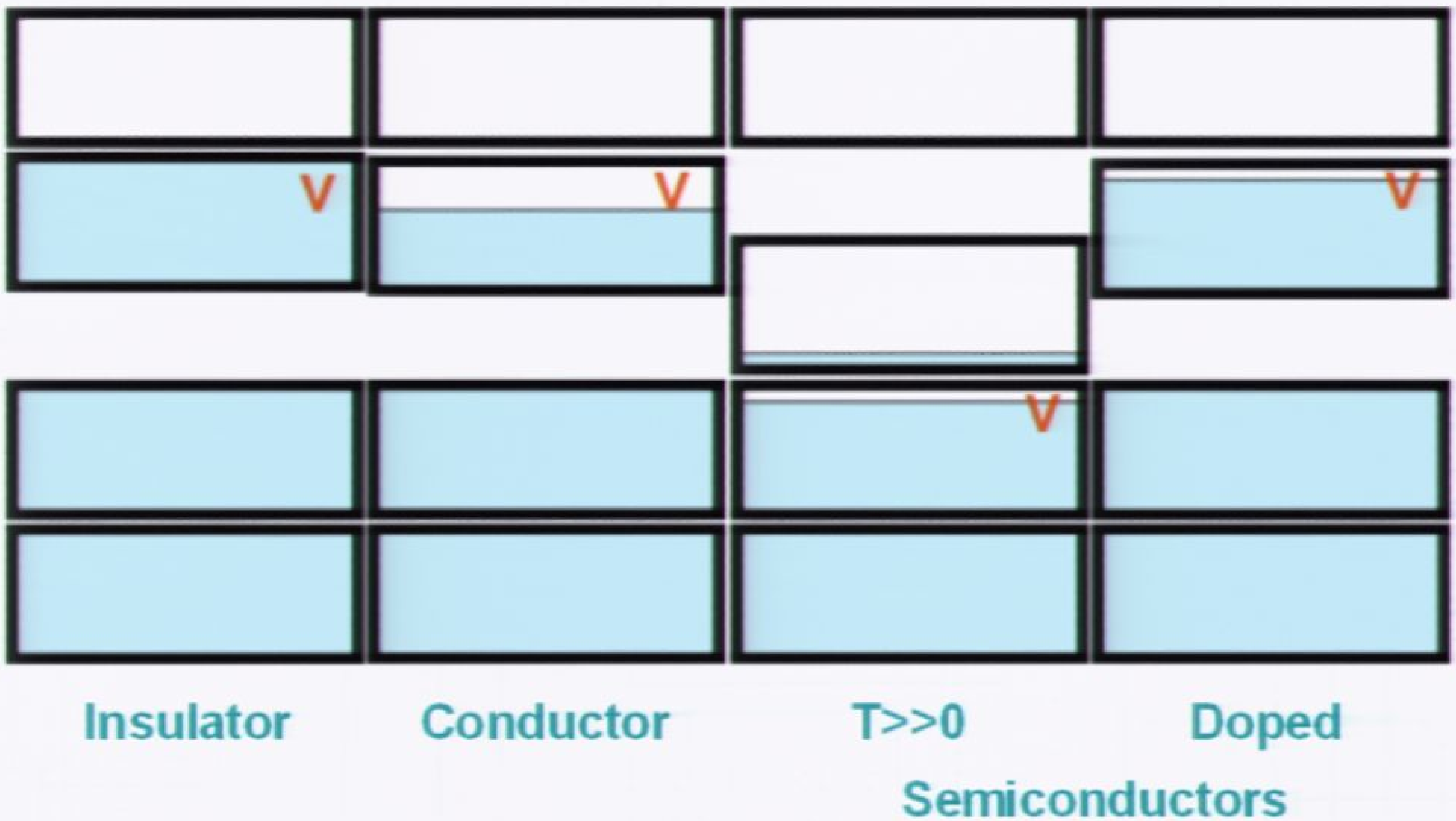

How does it work
Energy bands

Insulator | Conductor | T>>0 | Doped

Semiconductors

How does it work
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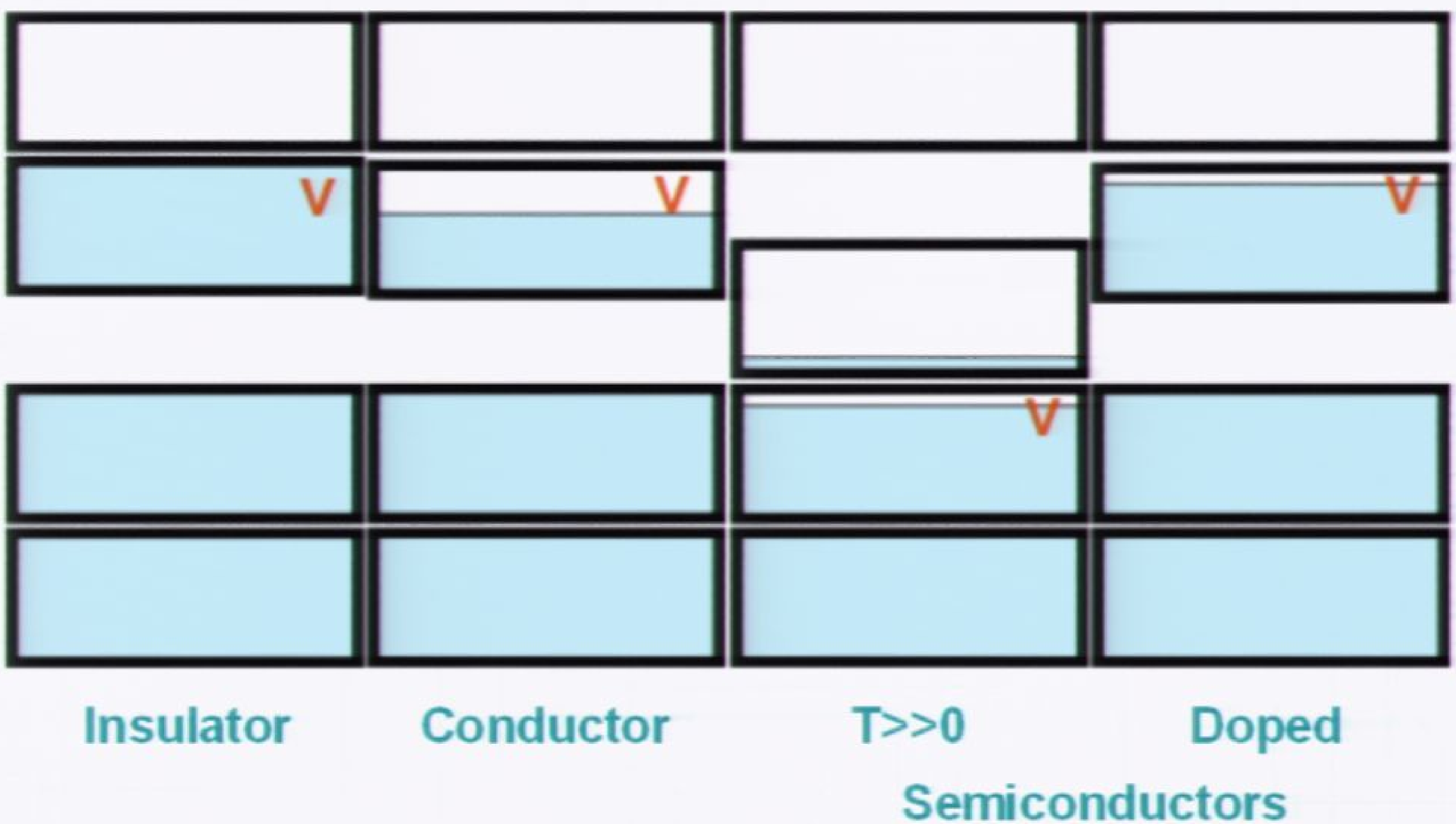

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Semiconductors

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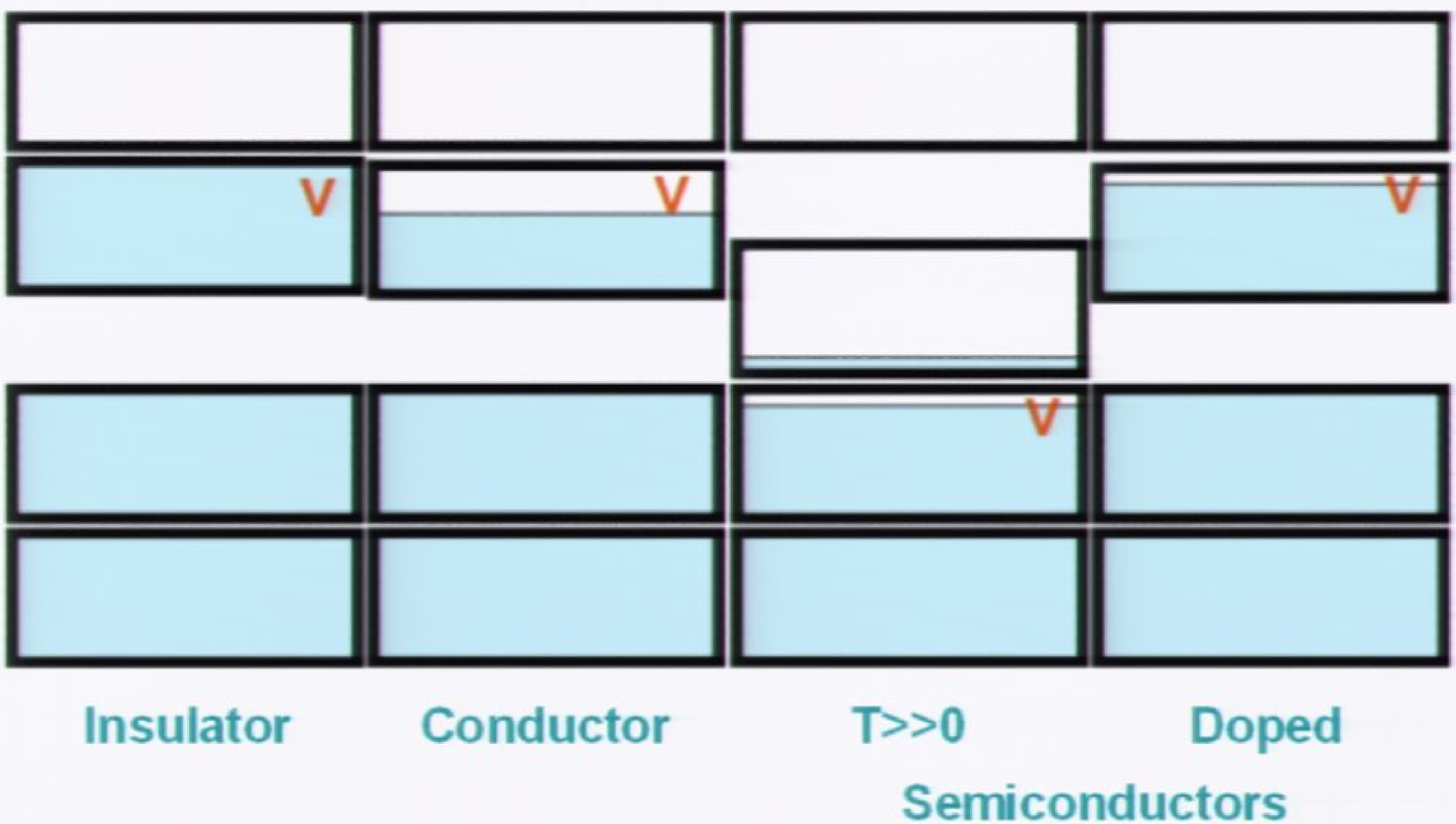

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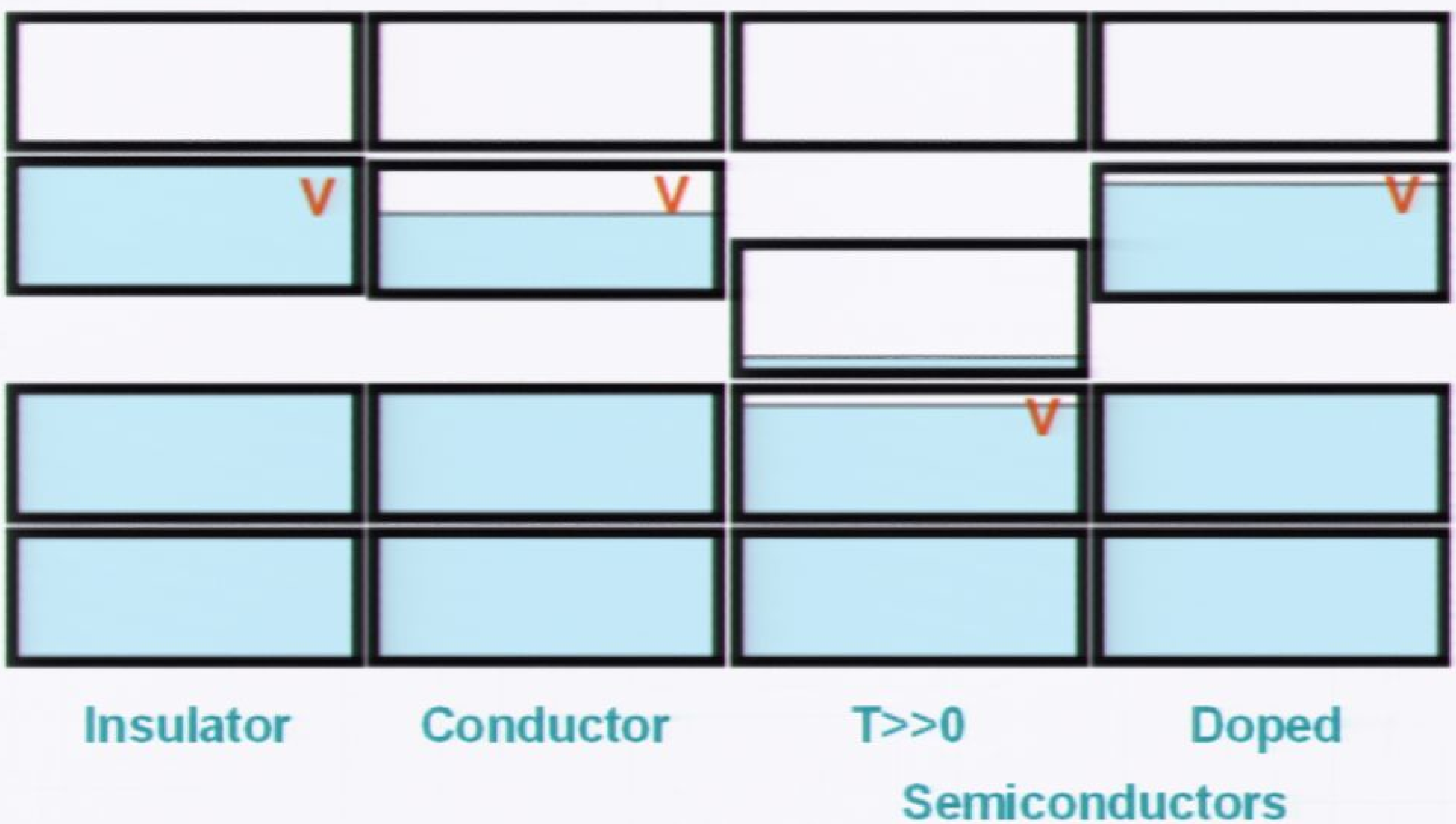

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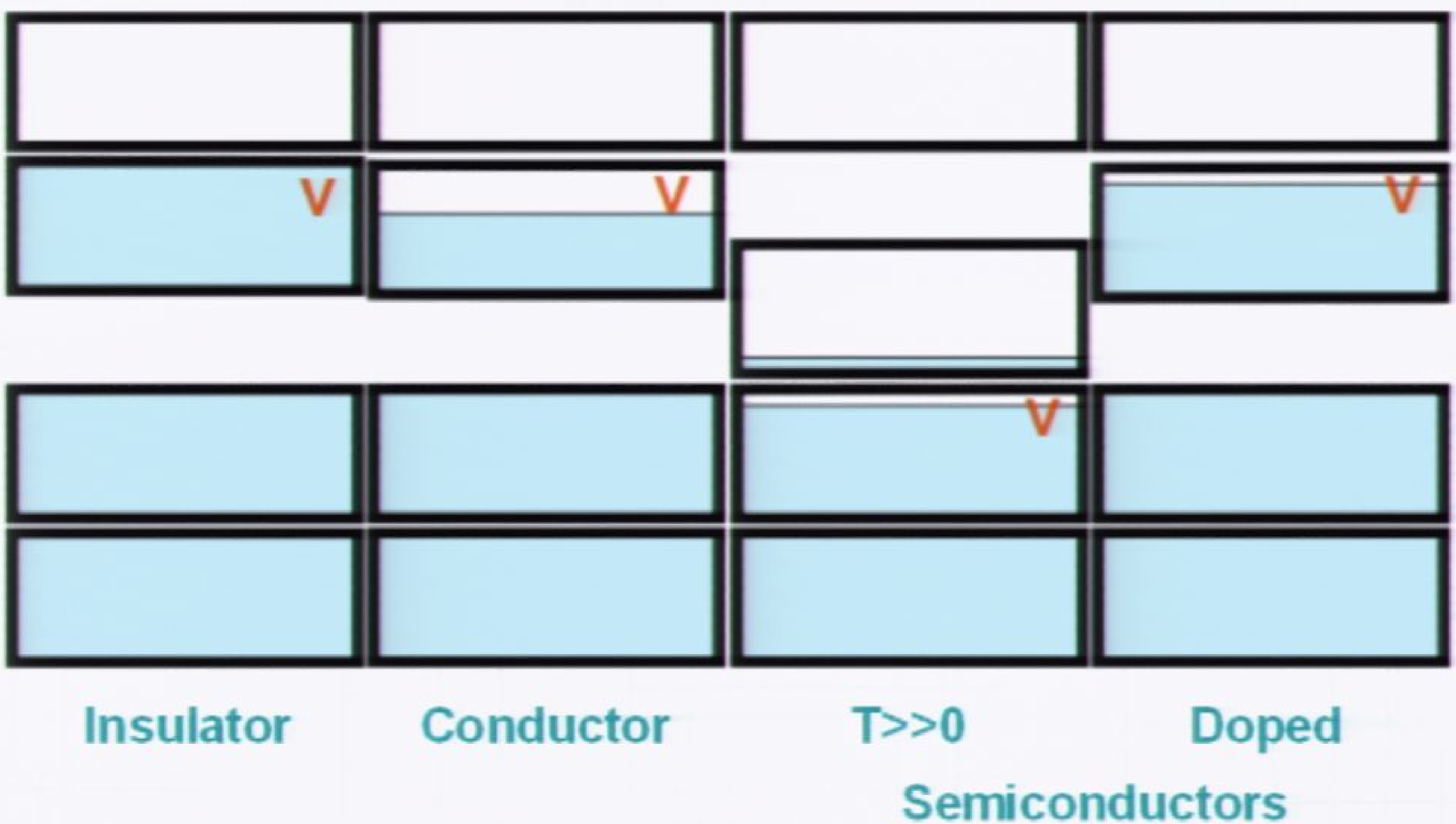

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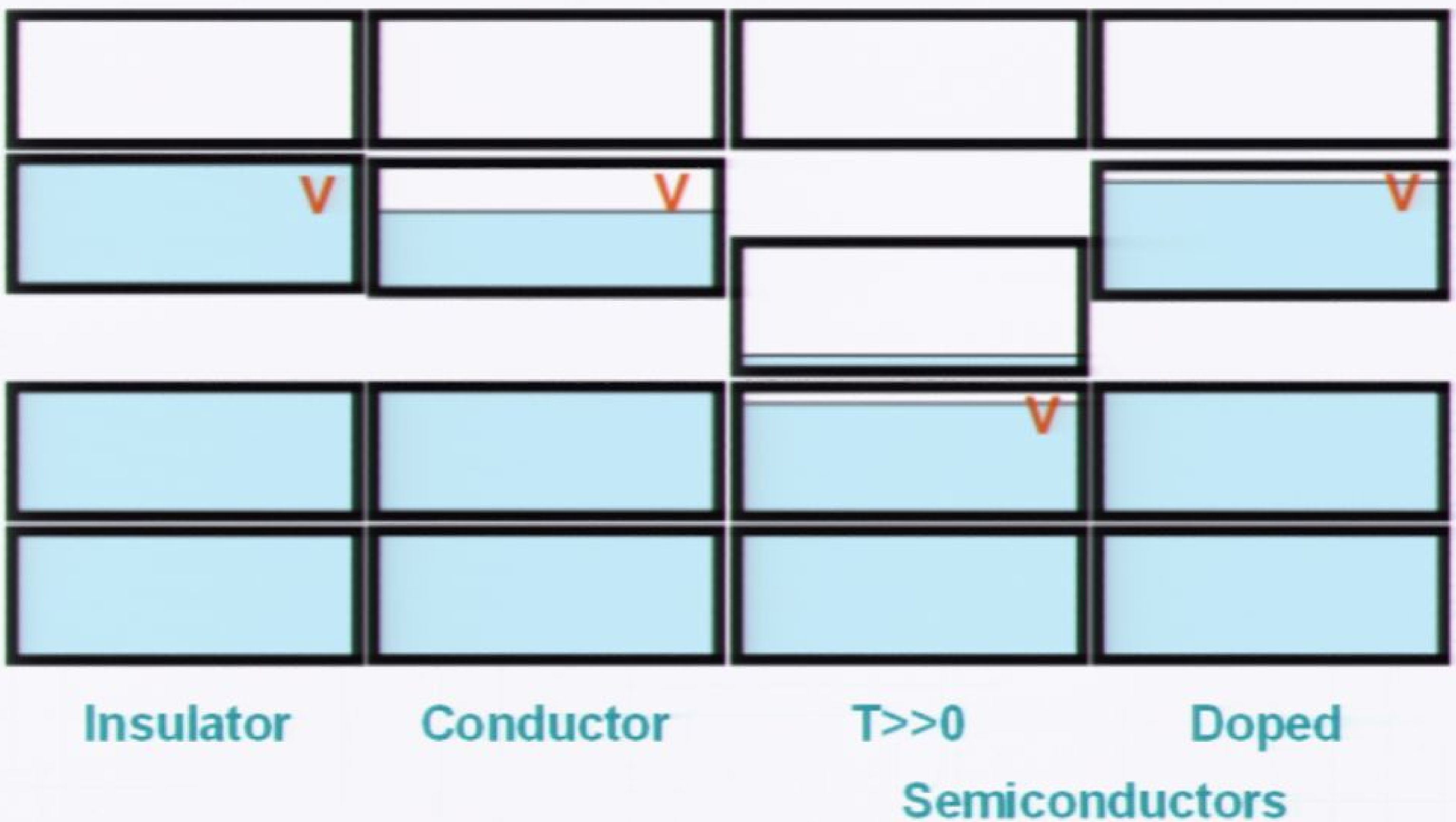
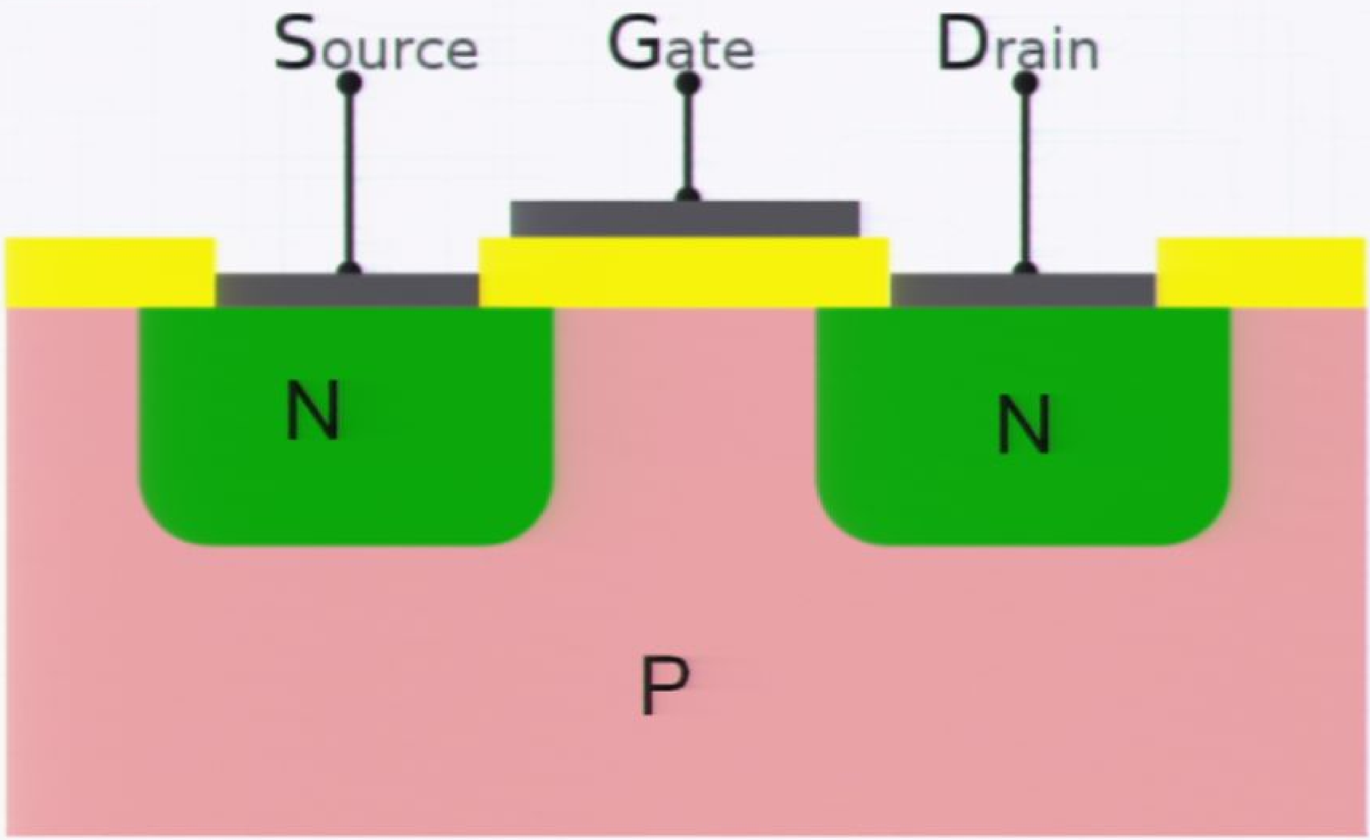


How does it work
Field effect transistor (MOSFET)



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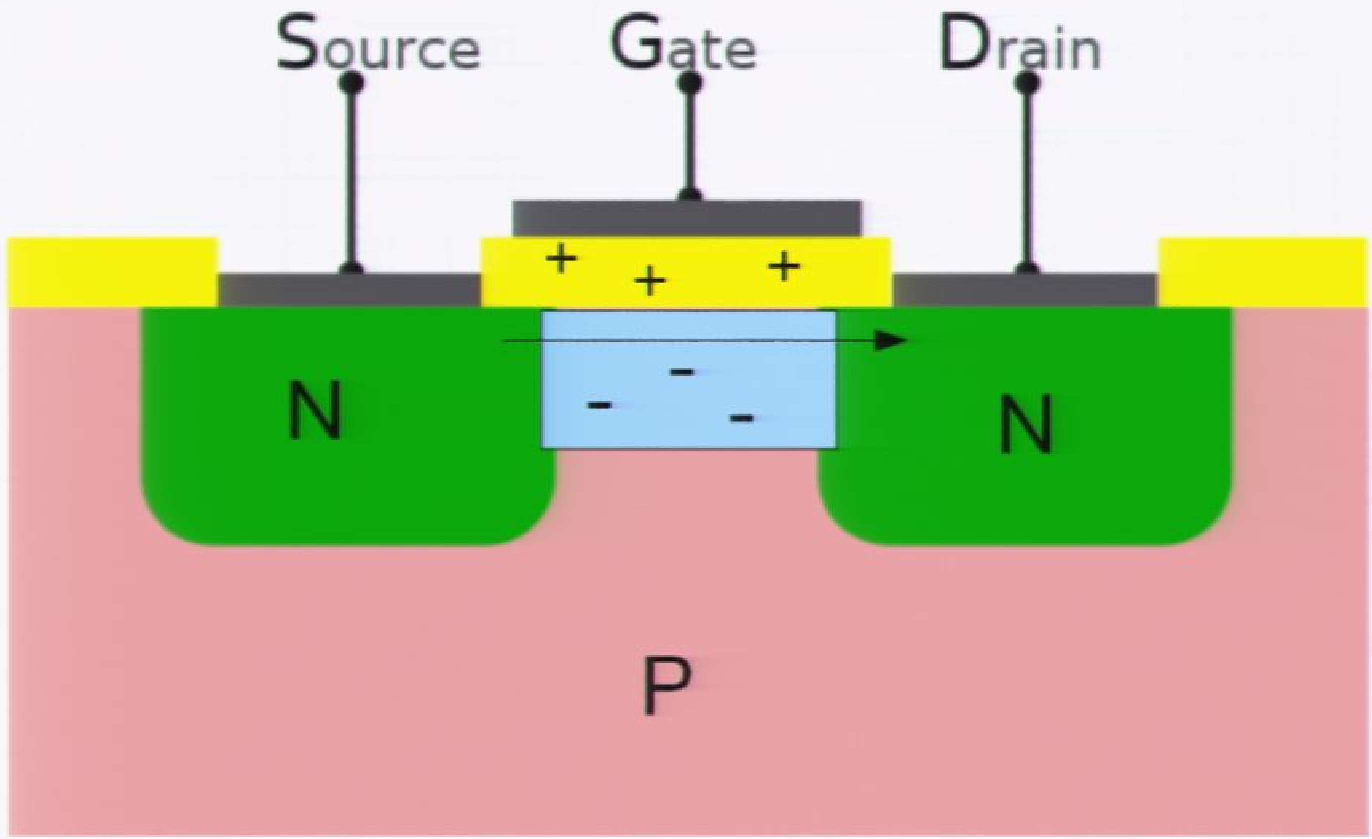
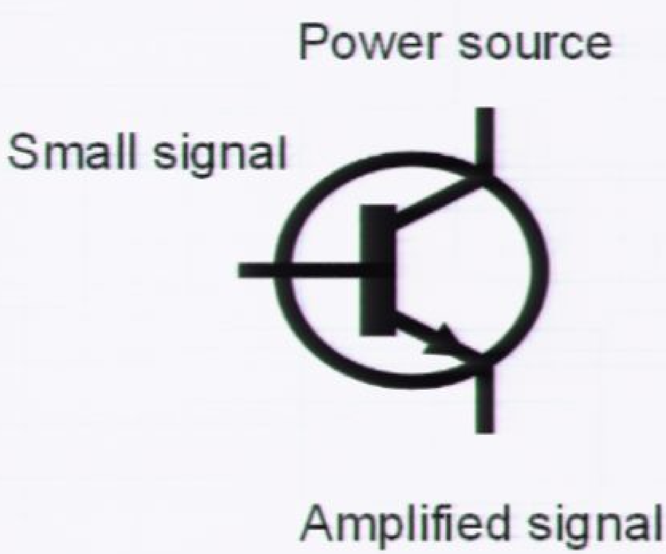
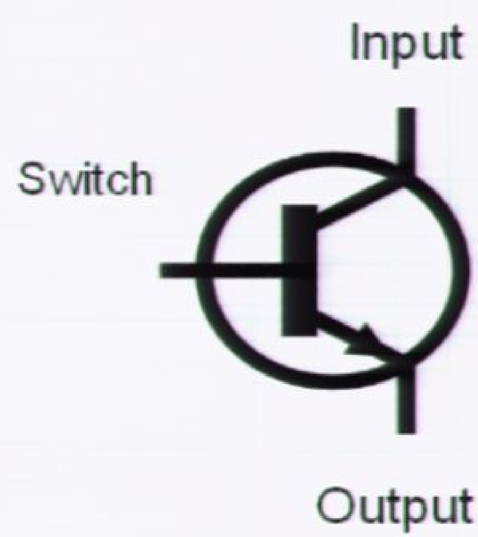


How to use them

- Amplification



- On/Off switch



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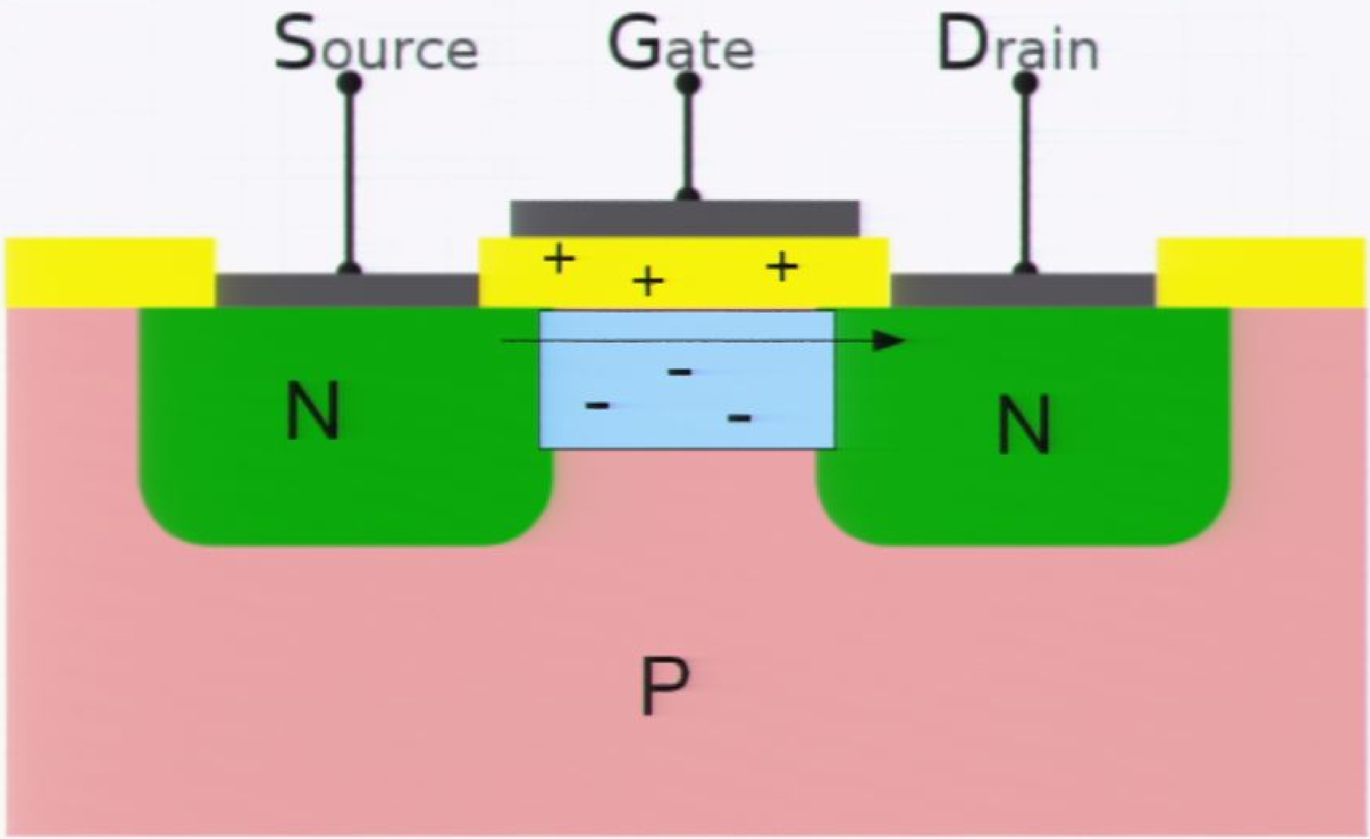

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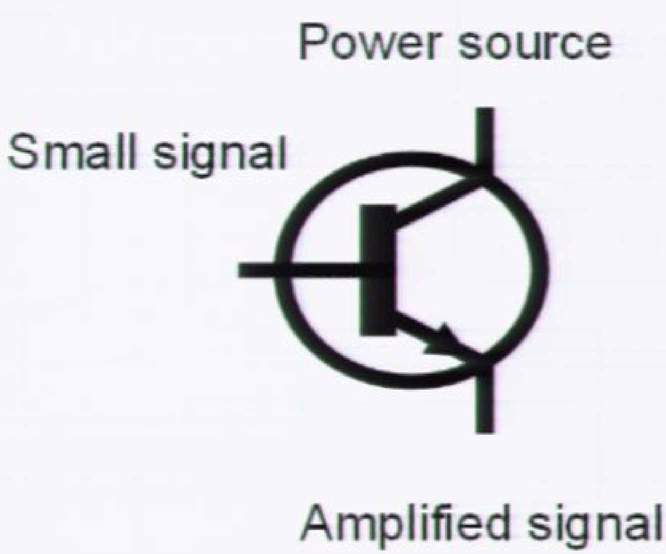

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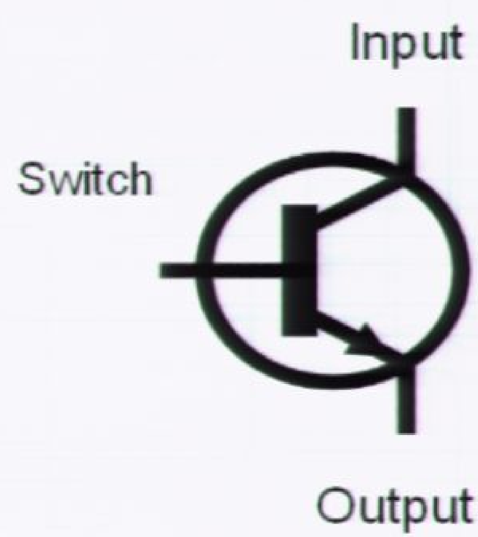
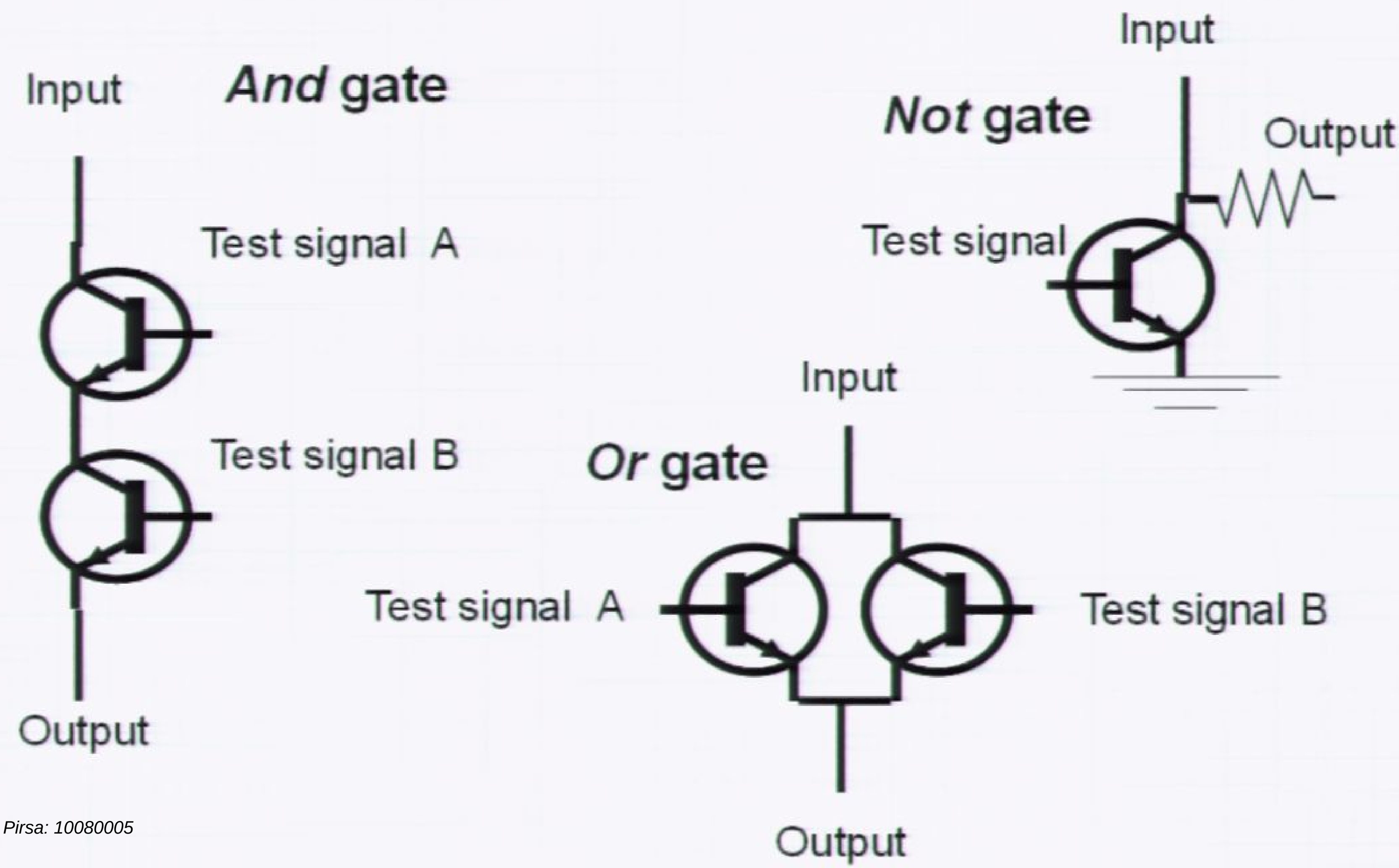


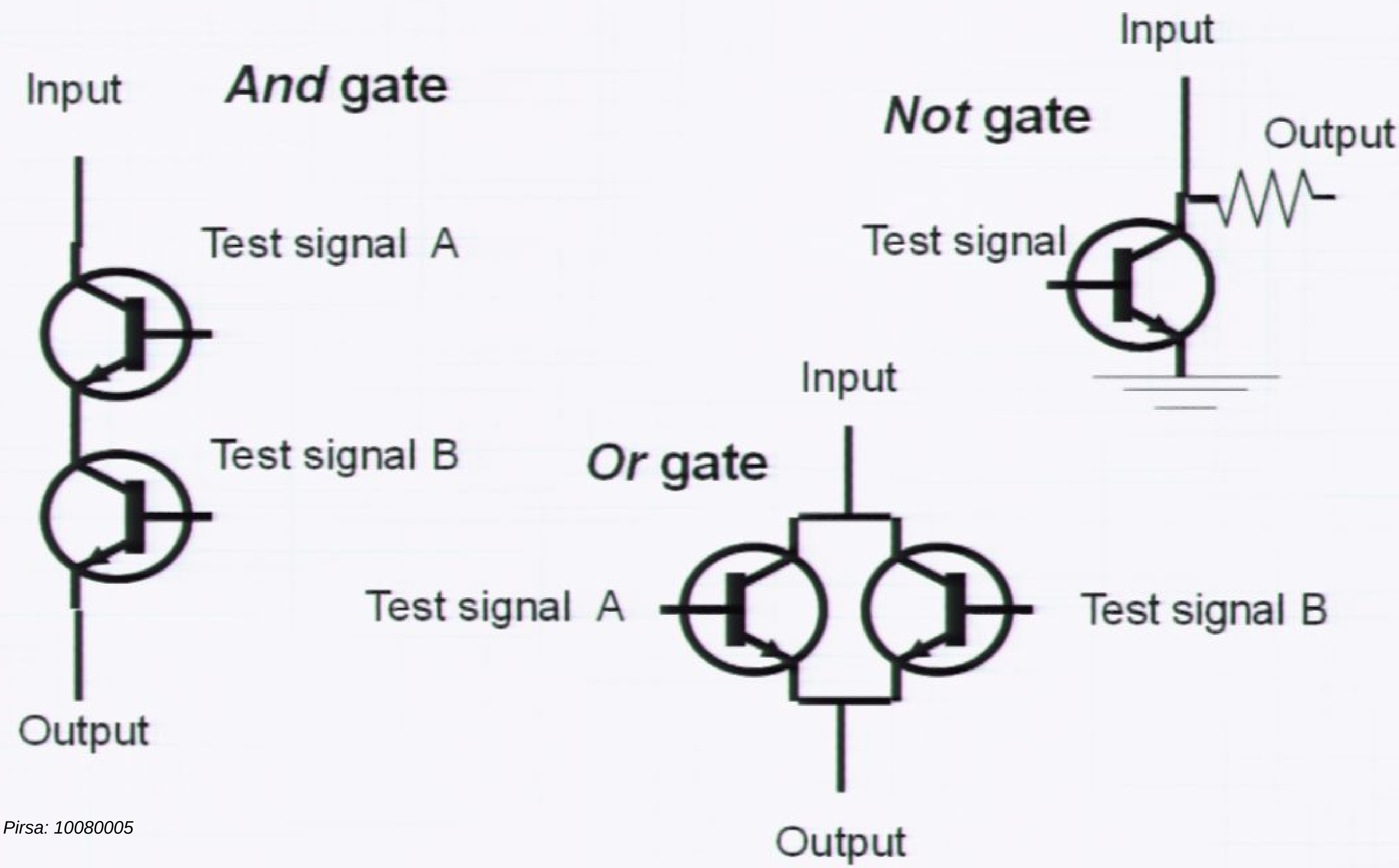
How to use them
Logic gates



Conclusion

- Important application of solid state physics
- Allows amplification of signals
- Useful device for logic and computation

How to use them
Logic gates



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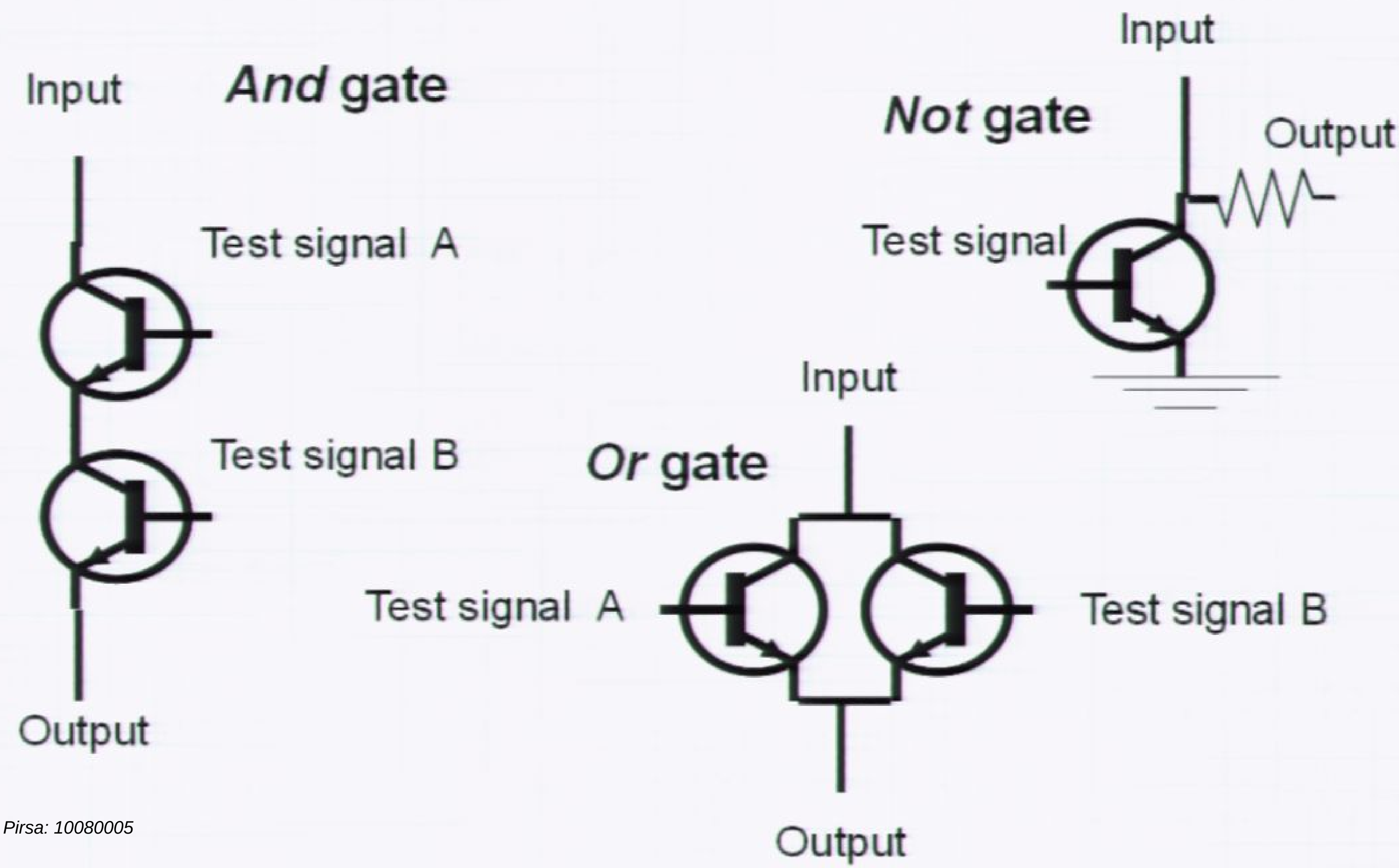

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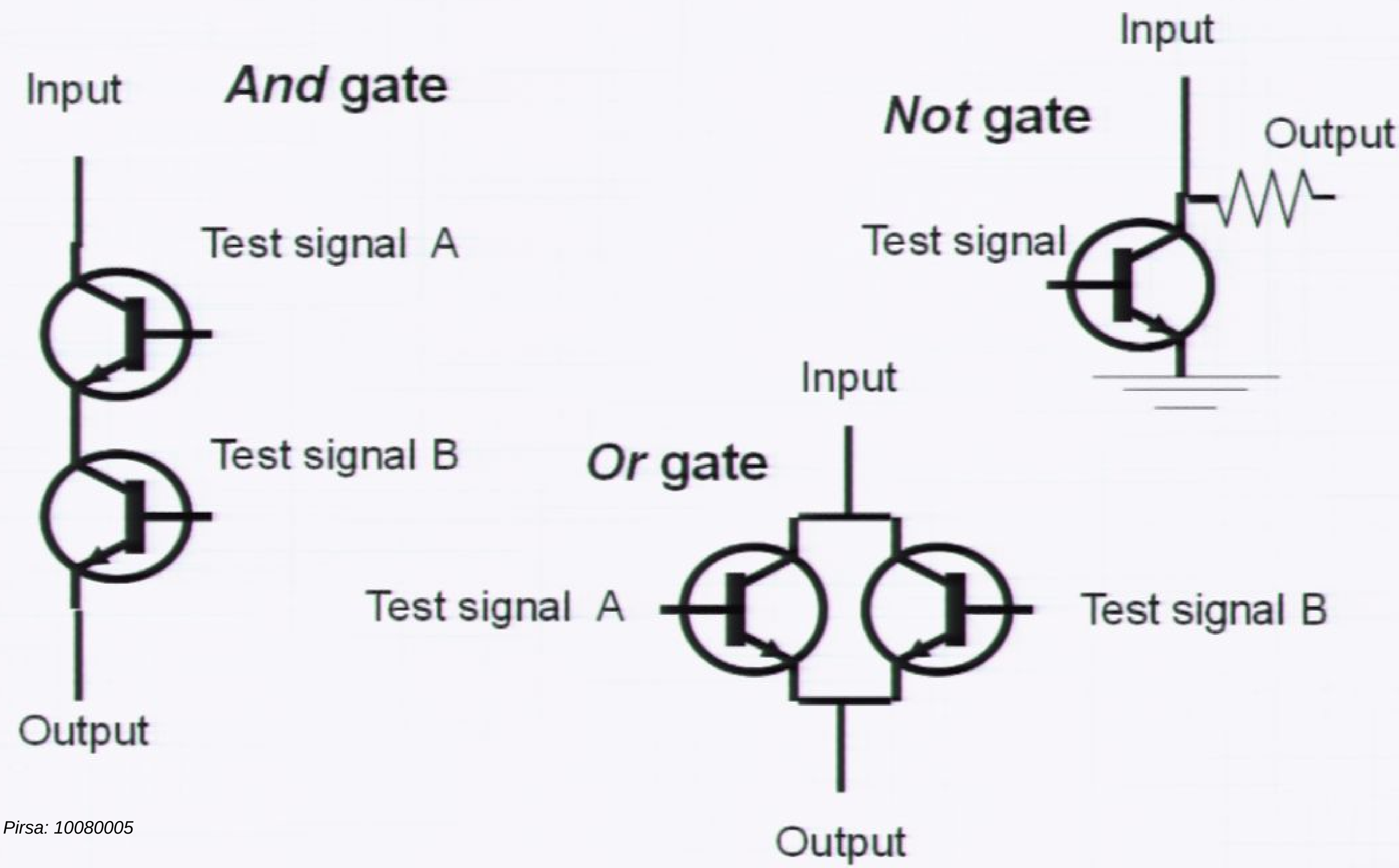

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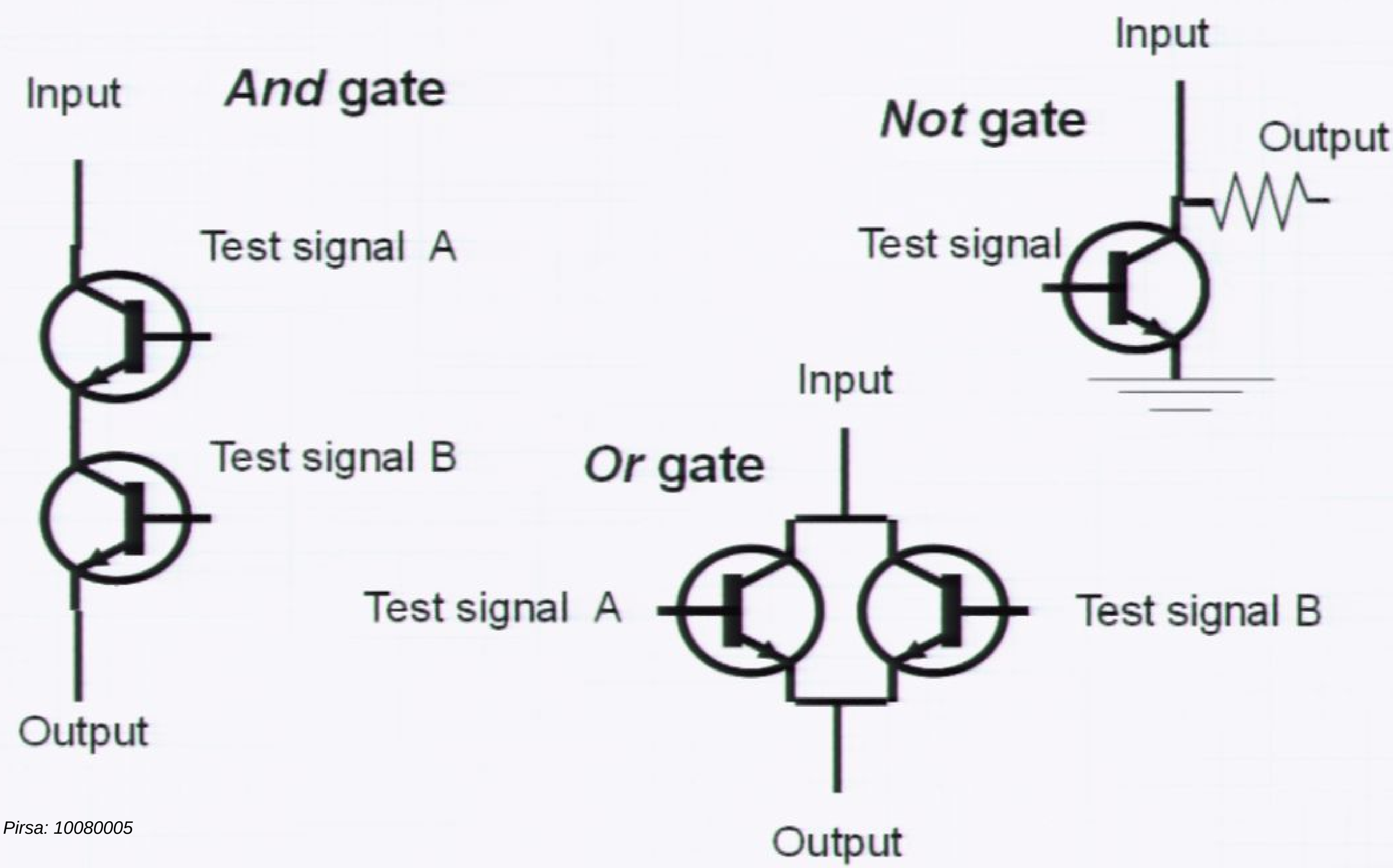

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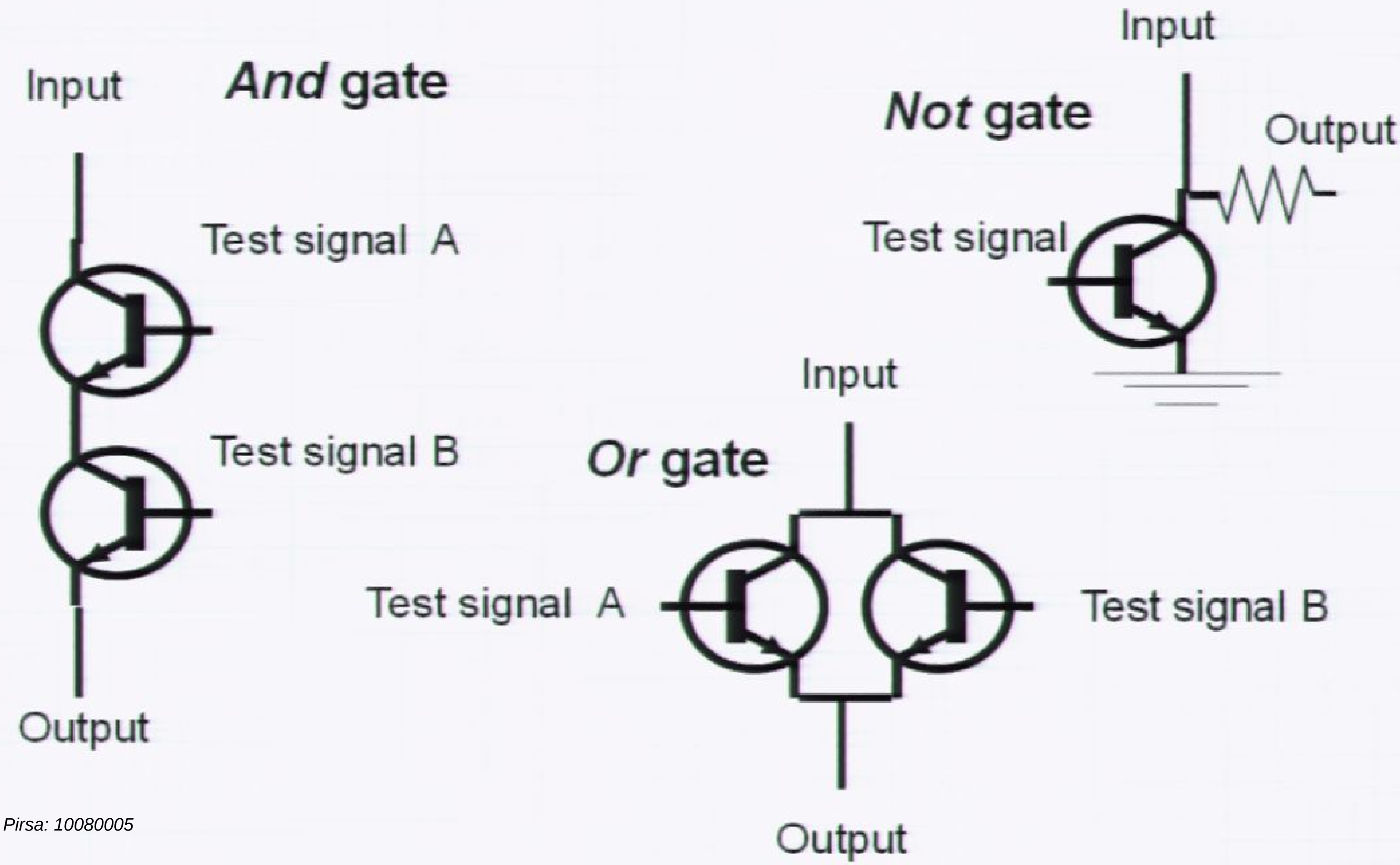

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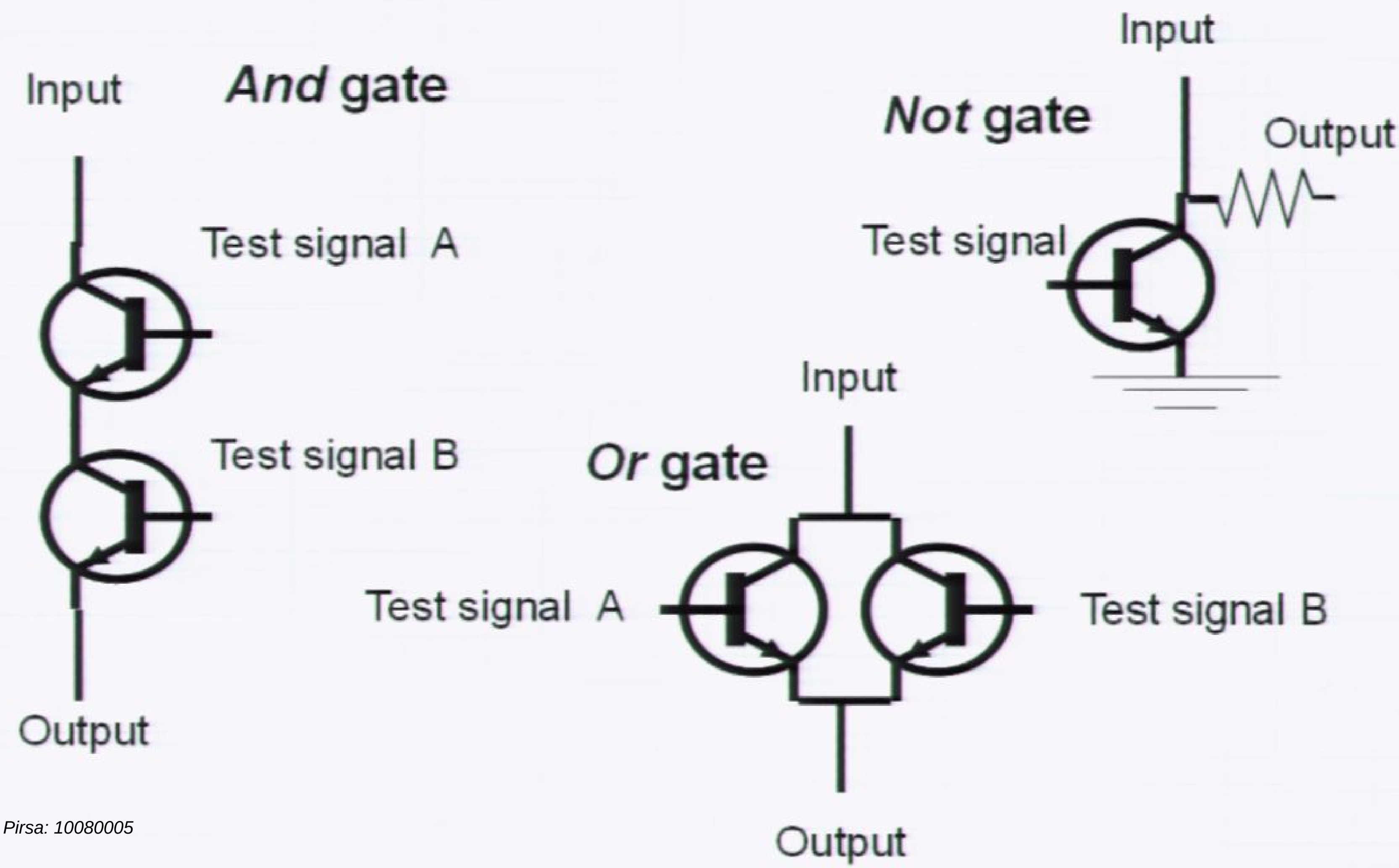

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How to use them

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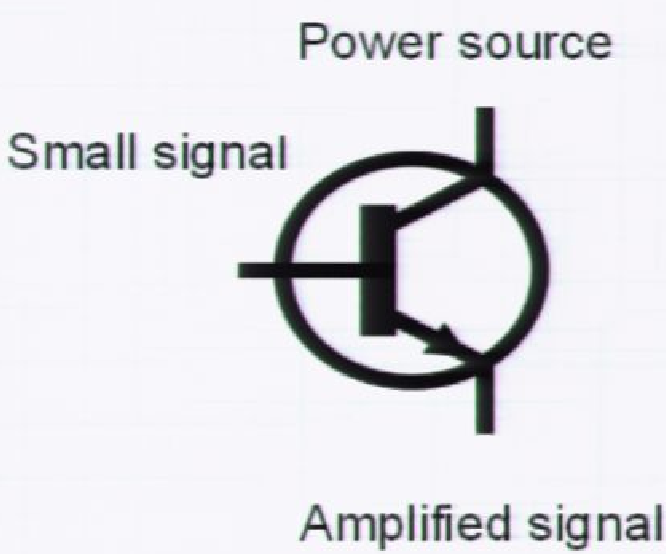
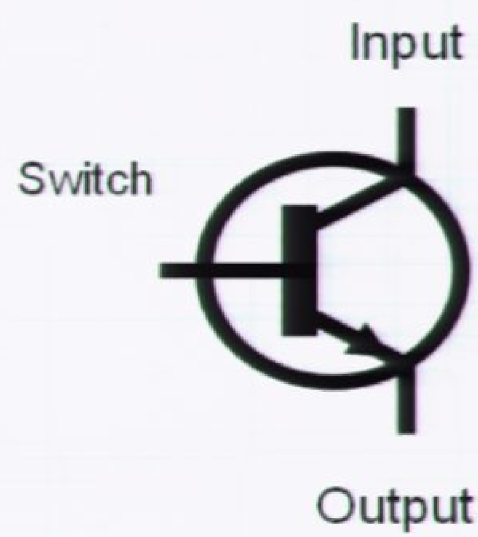


- On/Off switch



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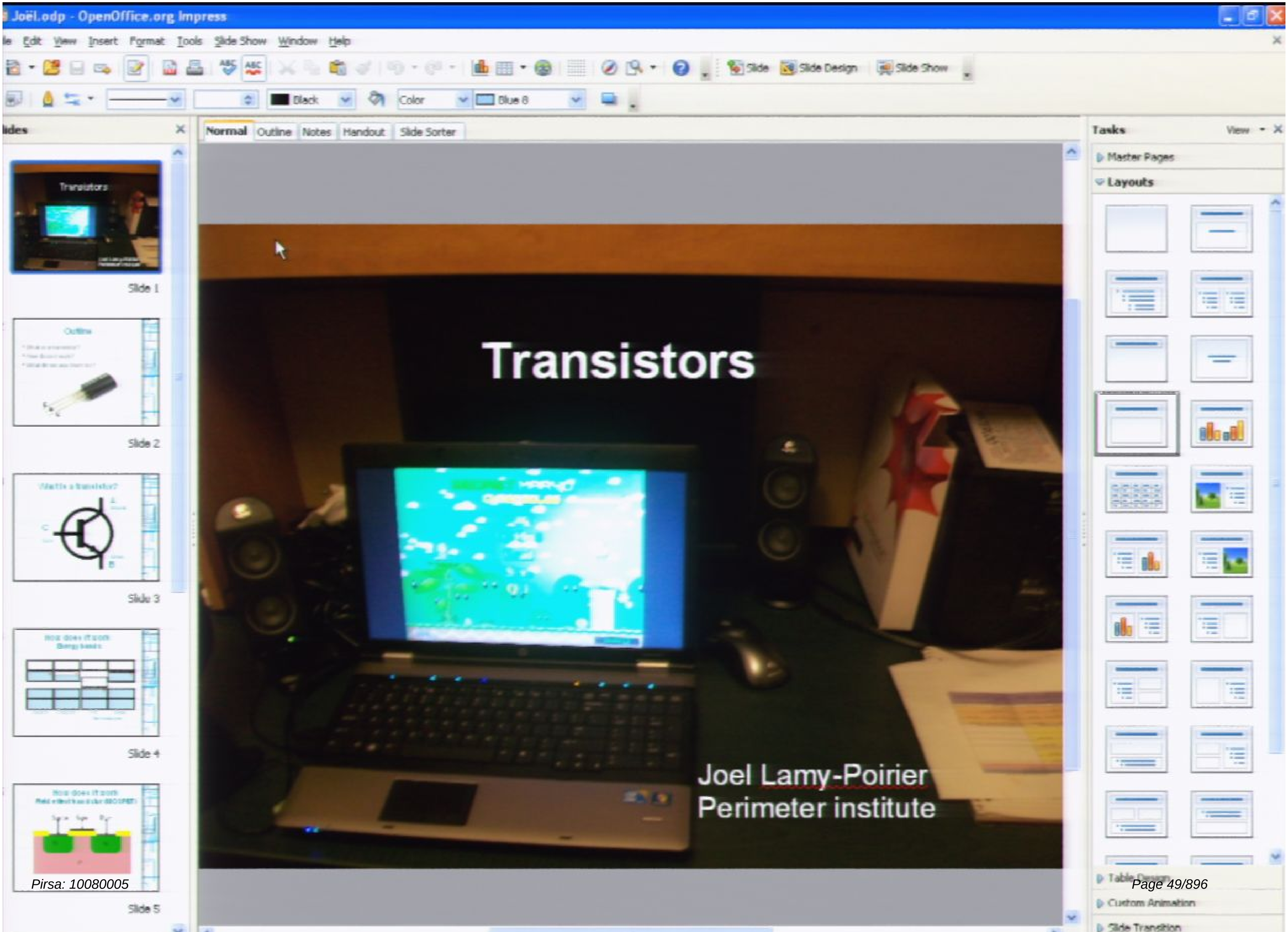
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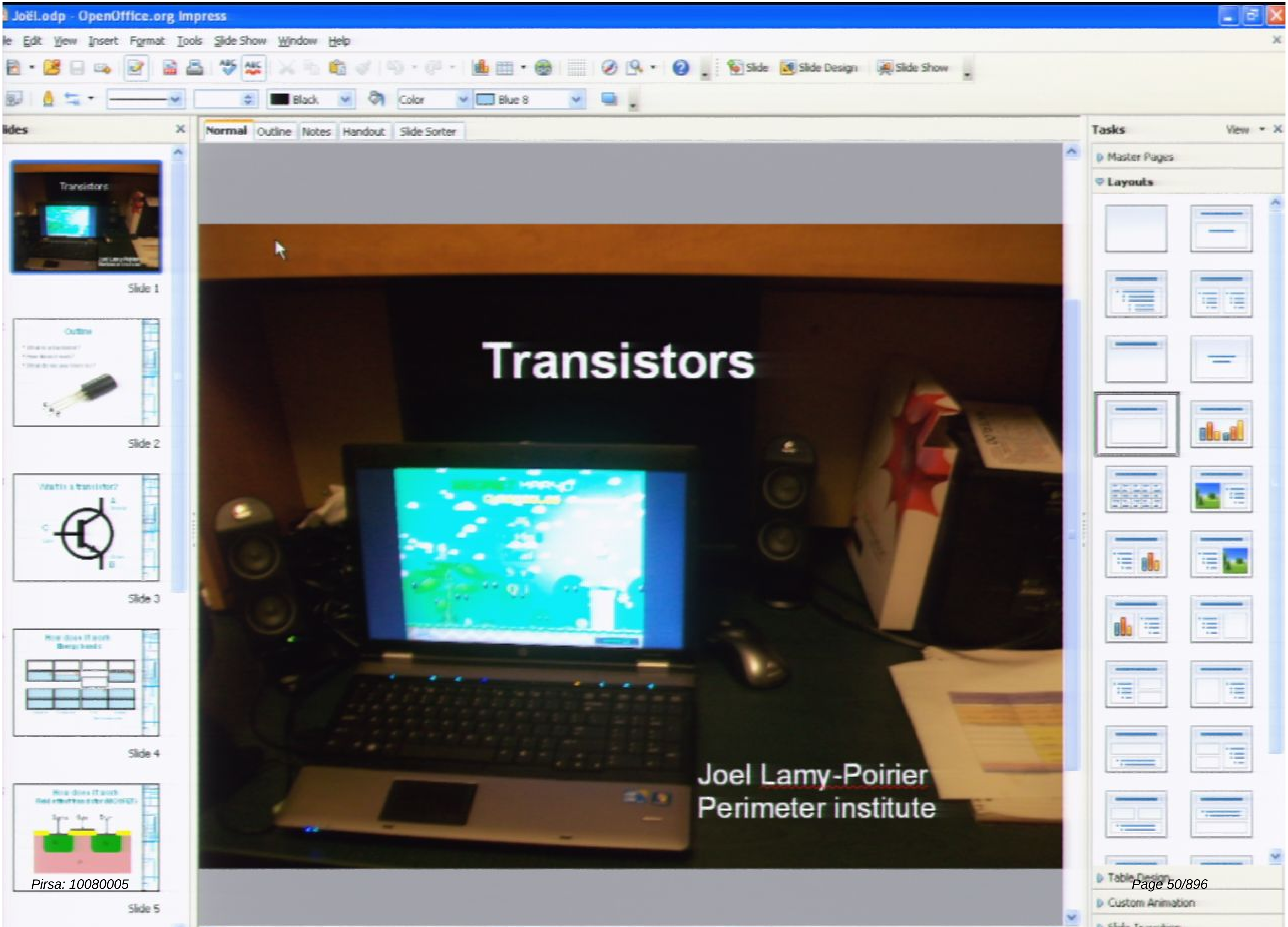
Transistors
Joel Lamy-Poirier
Perimeter institute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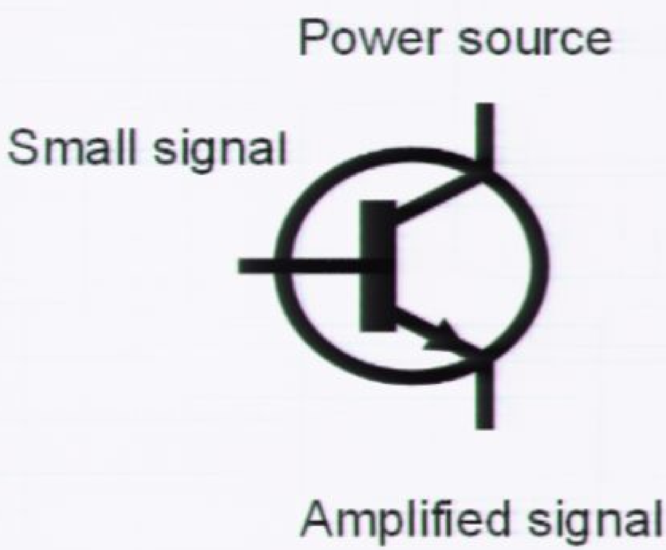
Slide 2
Slide 3
Slide 4
Slide 5
Custom Animation
Slide Transition

What is a transistor?

How to use them

- Amplification



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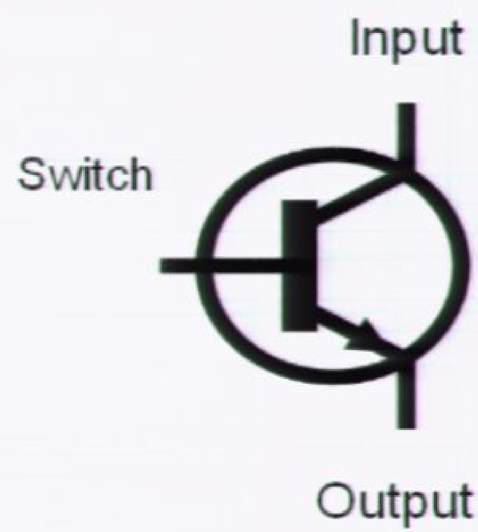
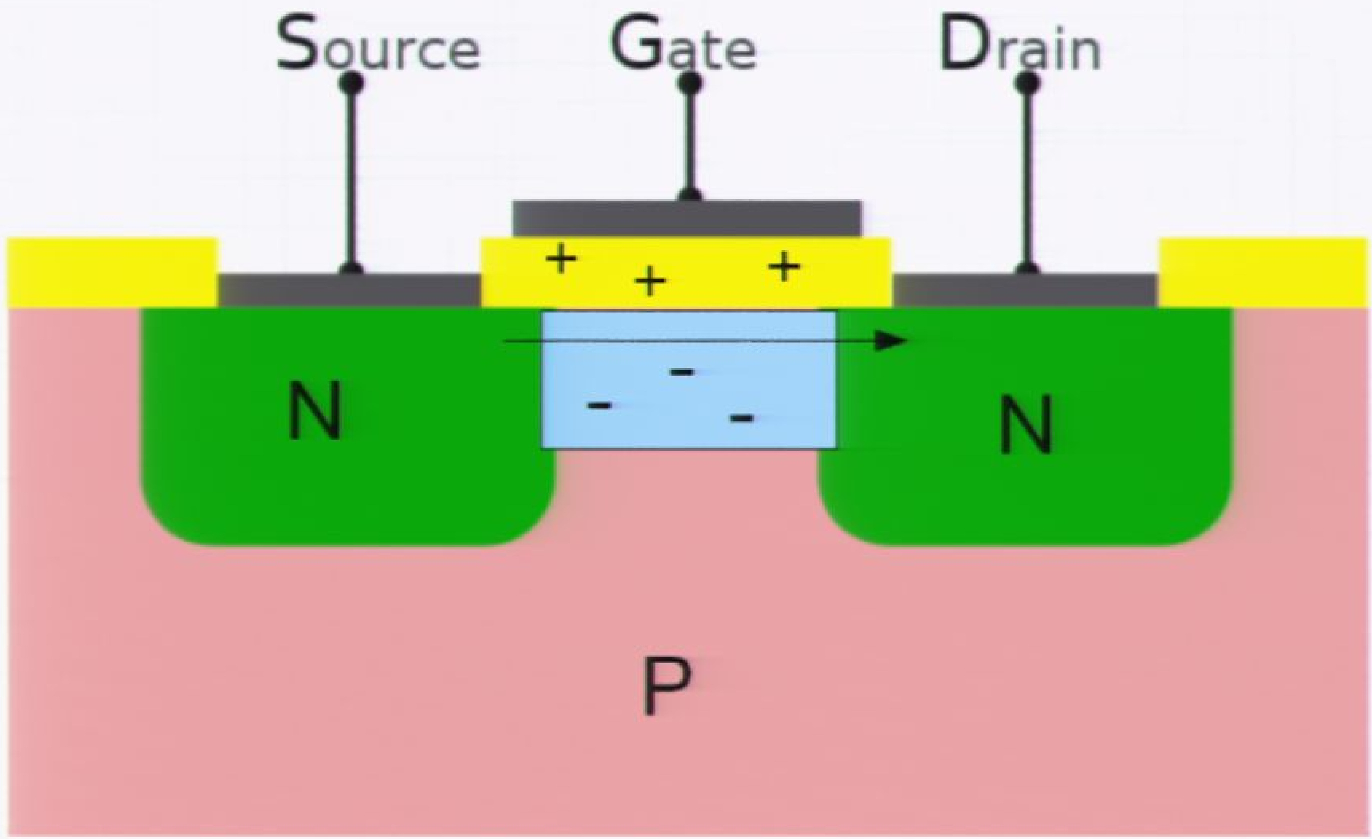


How does it work
Field effect transistor (MOSFET)



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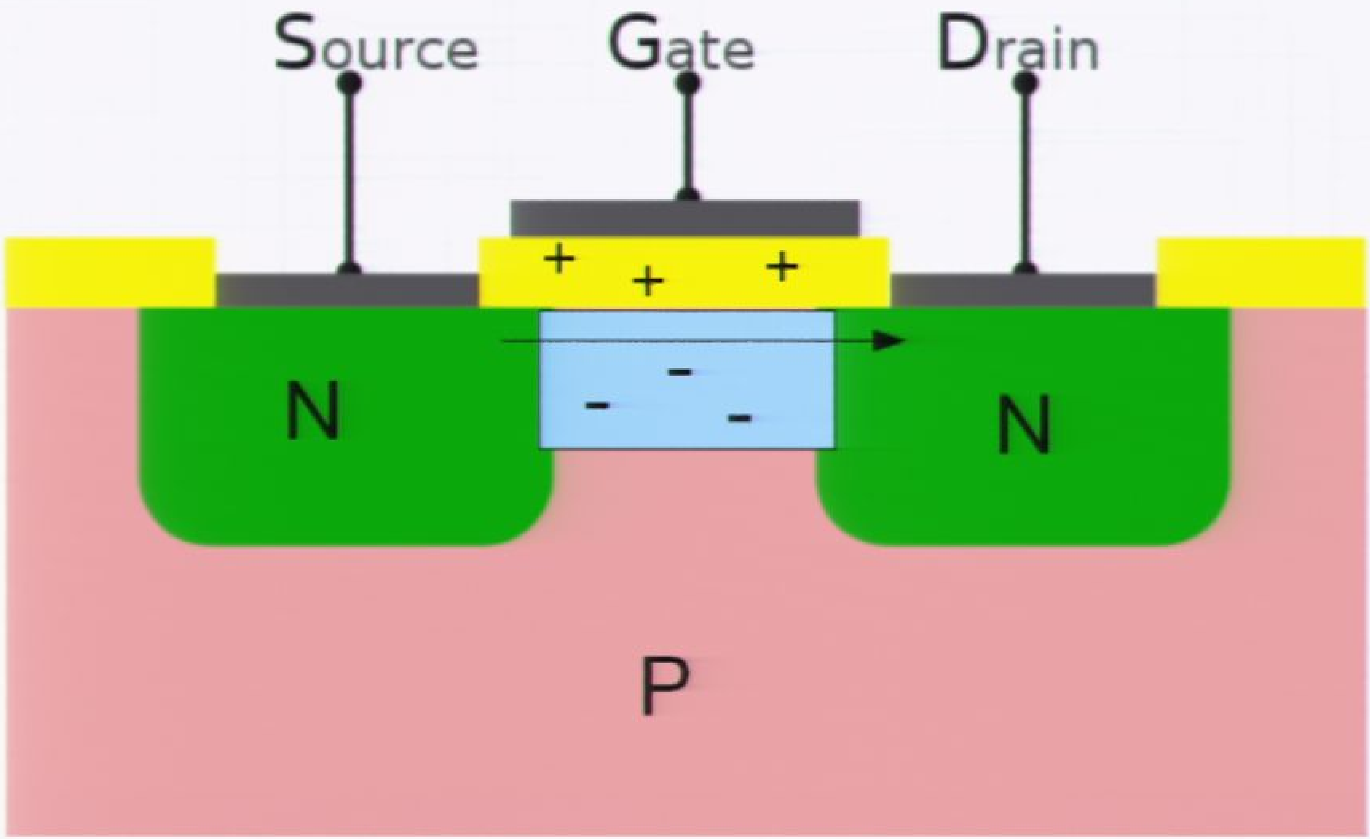

How to use them

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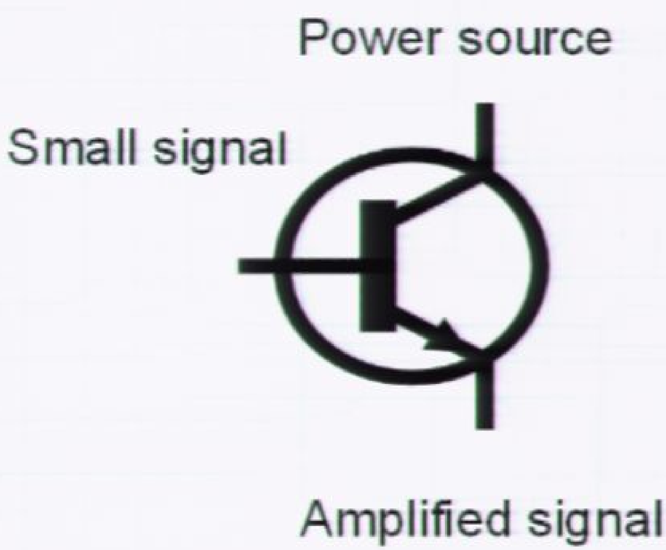

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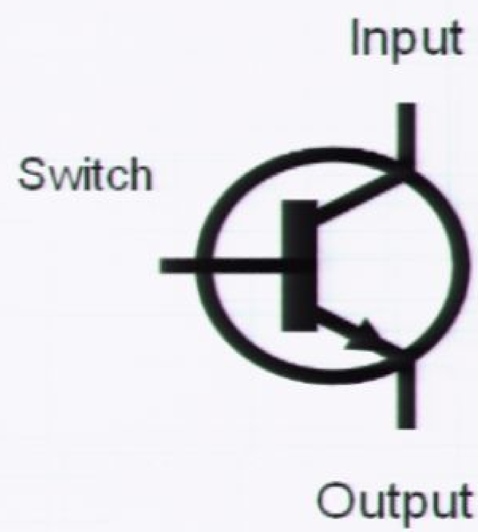

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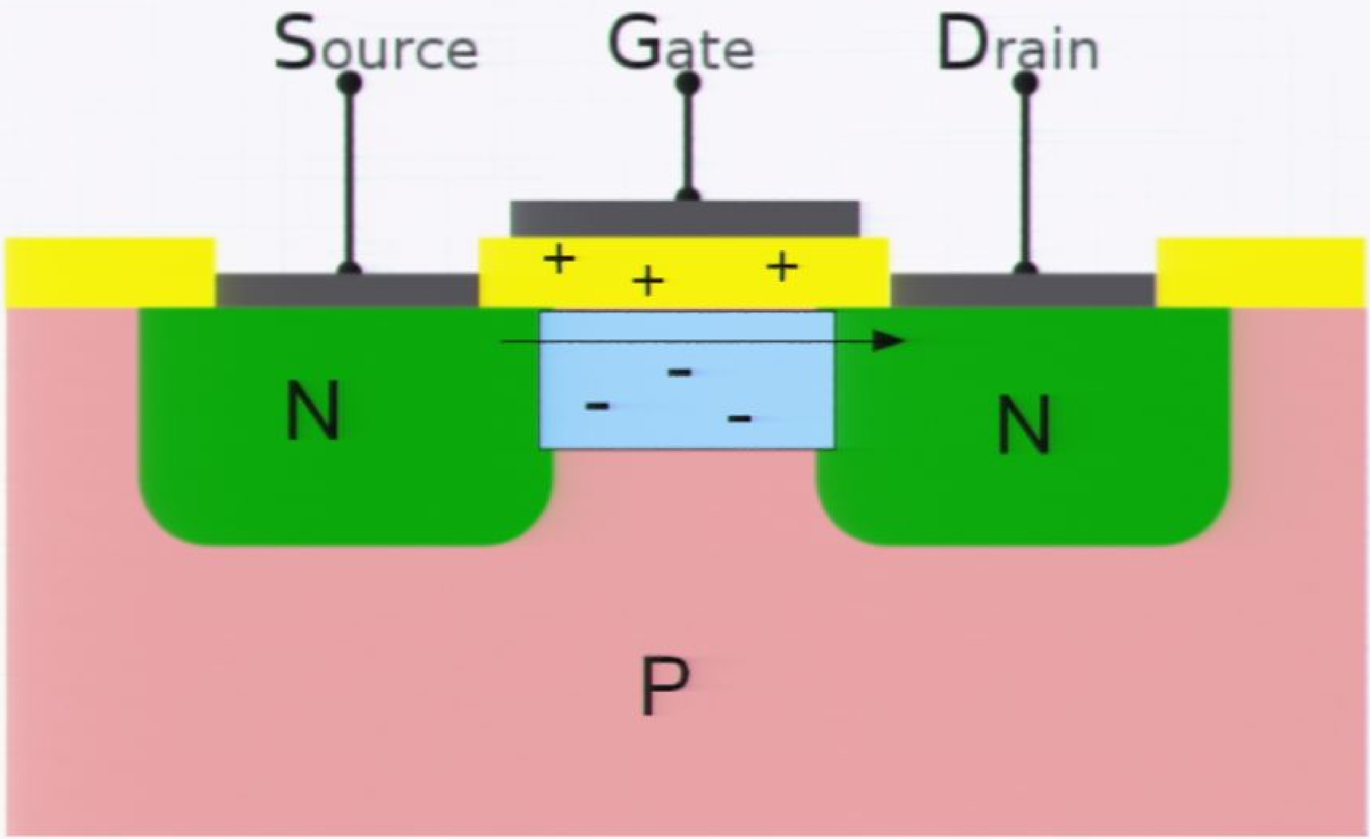

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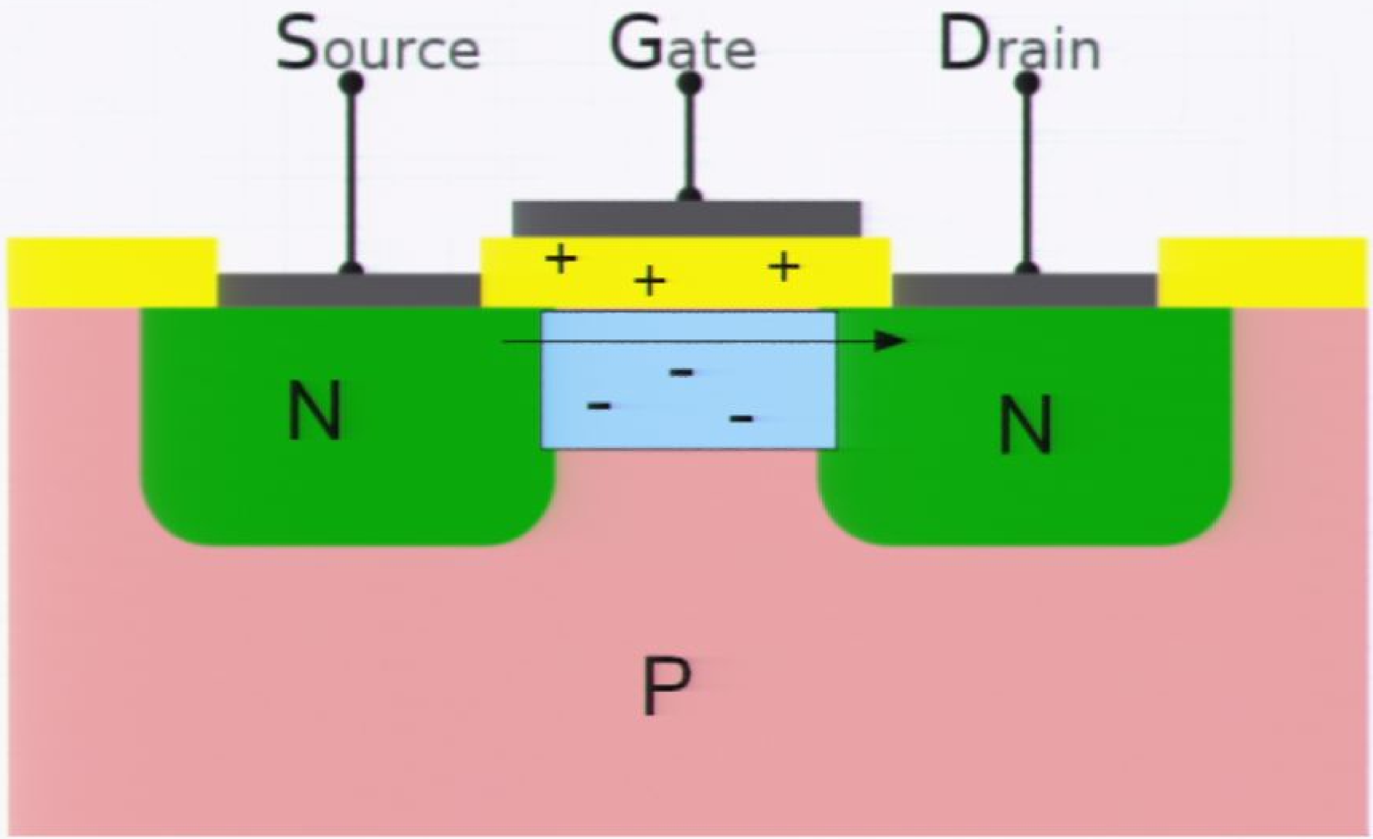
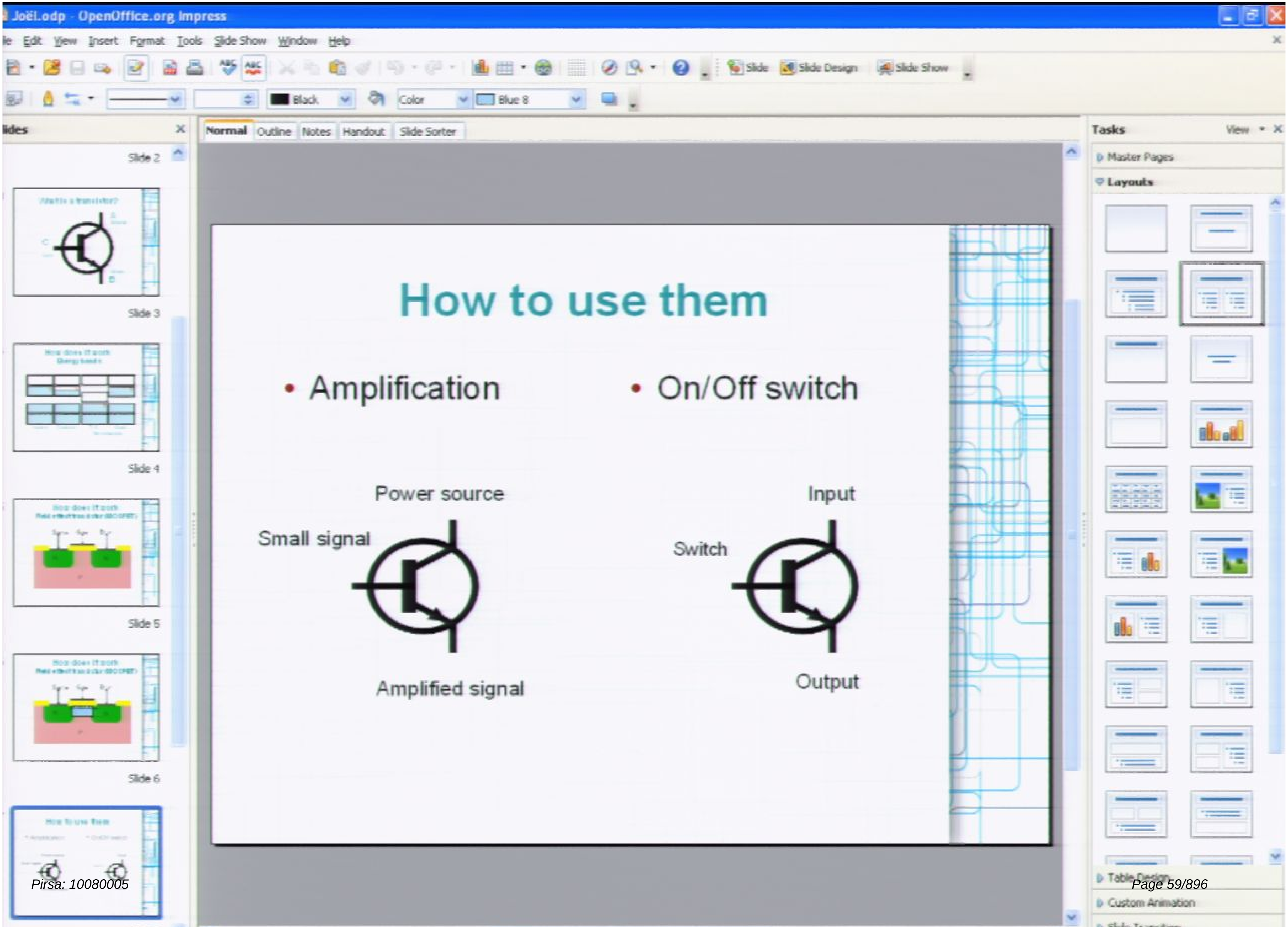


How to use them

- Amplification
- On/Off switch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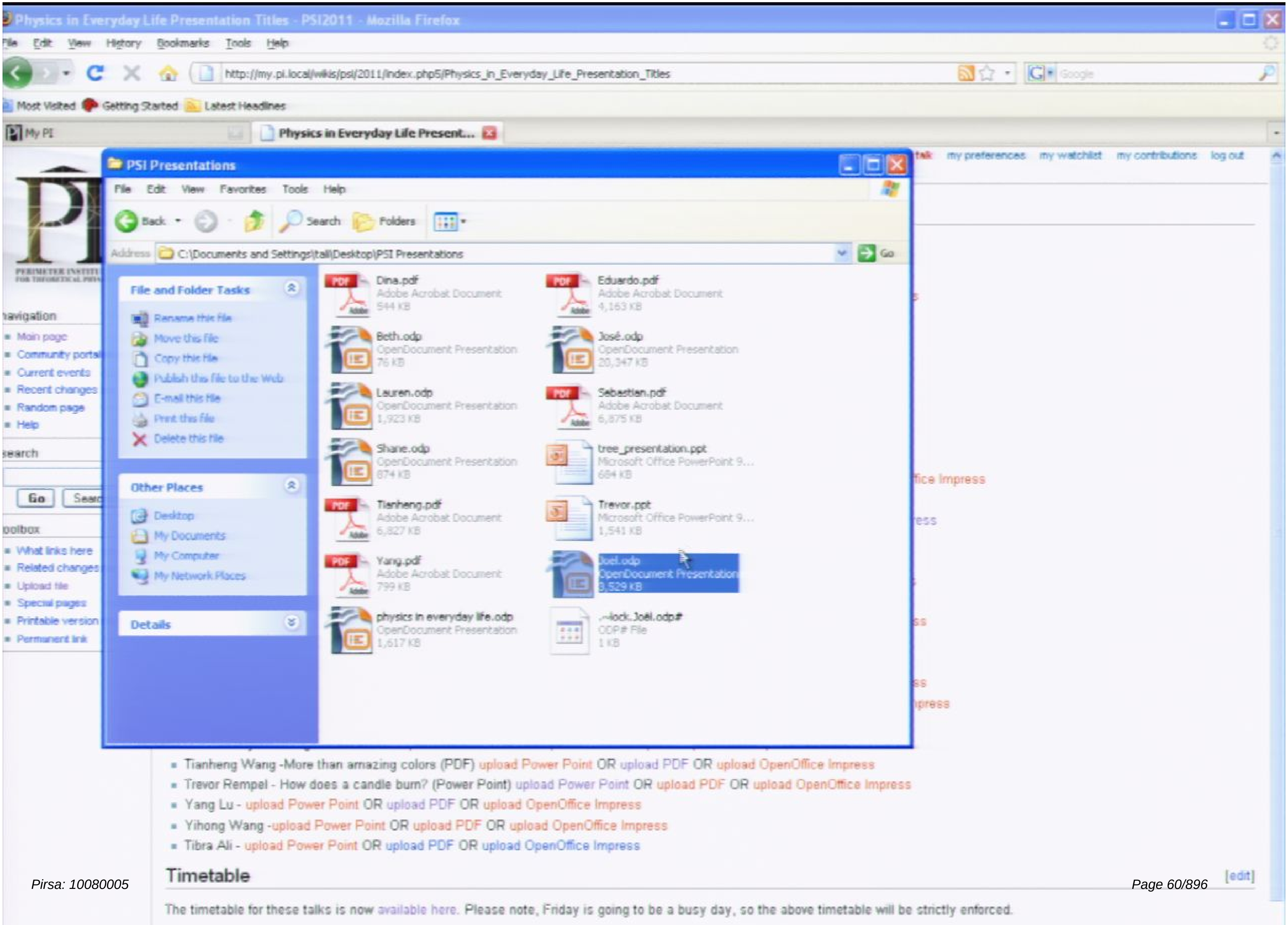
How to use them
• Amplification
• On/Off switch
Power source
Small signal
Amplified signal
Input
Switch
Output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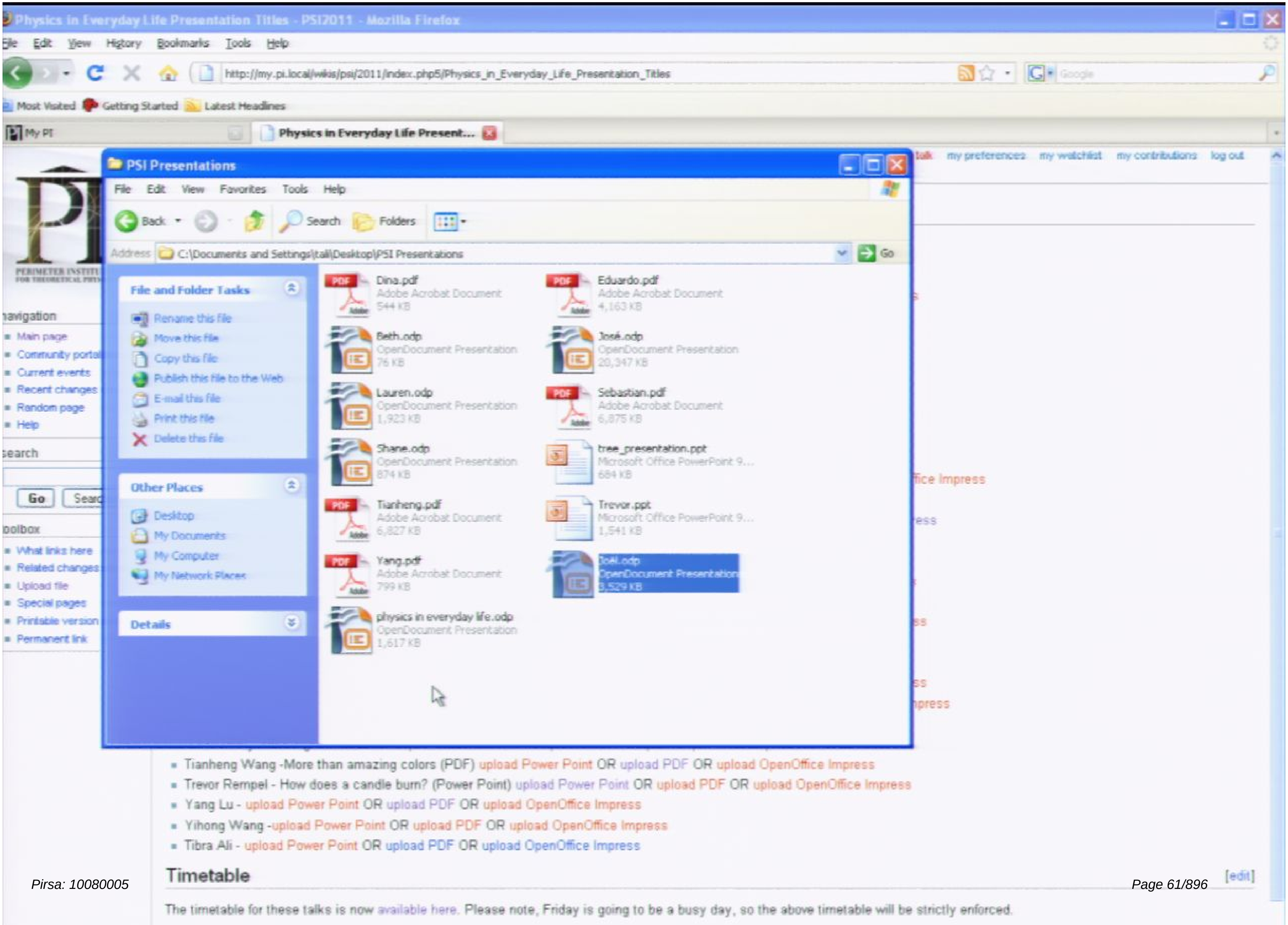
Timetable
[edit]
The timetable for these talks is now available here. Please note, Friday is going to be a busy day, so the above timetable will be strictly enforced.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1. Colorful Nature
    - Amazing Colors in Nature
    - Microstructure of Opal

2. Creative Human
    - Concept of Photonic Crystal
    - Design Your Photonic Crystal
    - Unexpected New Phenomena

Photonic Crystal, More Than Amazing Colors

Tianheng Wang

August 20, 2010

Photonic Crystal, More Than Amazing Colors

Tianheng Wang

August 20, 2010

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   - Microstructure of Opal

2. Creative Human
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   - Design Your Photonic Crystal
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Amazing Colors in Nature

Opal

Taken by me
Not attractive at all

Amazing Colors in Nature

Opal

Taken by me
Not attractive at all

Precious Opal

Shining stone

Amazing Colors in Nature

Opal

Taken by me
Not attractive at all

Precious Opal

Shining stone

Butterfly

Cute creature

Why are they colorful?

Amazing Colors in Nature

Opal

Taken by me
Not attractive at all

Precious Opal

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Butterfly

Cute creature

Why are they colorful?

Amazing Colors in Nature

Opal

Taken by me
Not attractive at all

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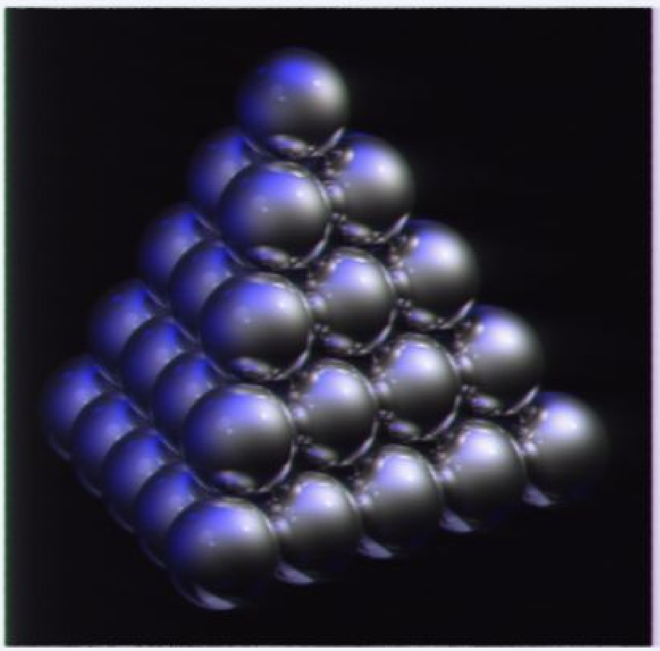

Spheres of sillica of fairly regular size

Hexagonal or cubic close-packed lattice

Variable interplay of internal colors

Microstructure of Opal

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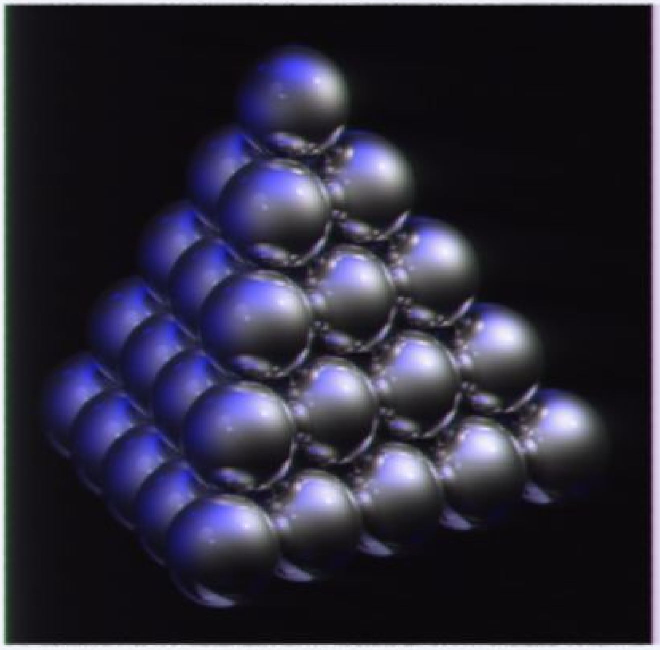

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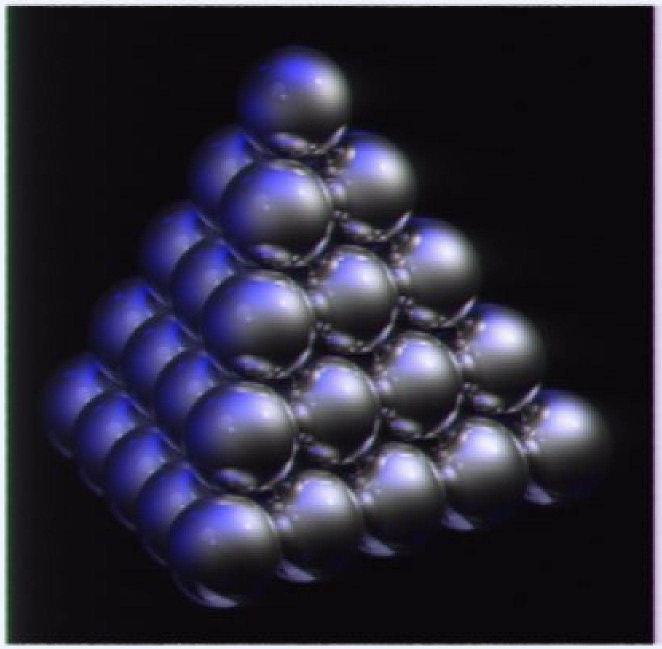

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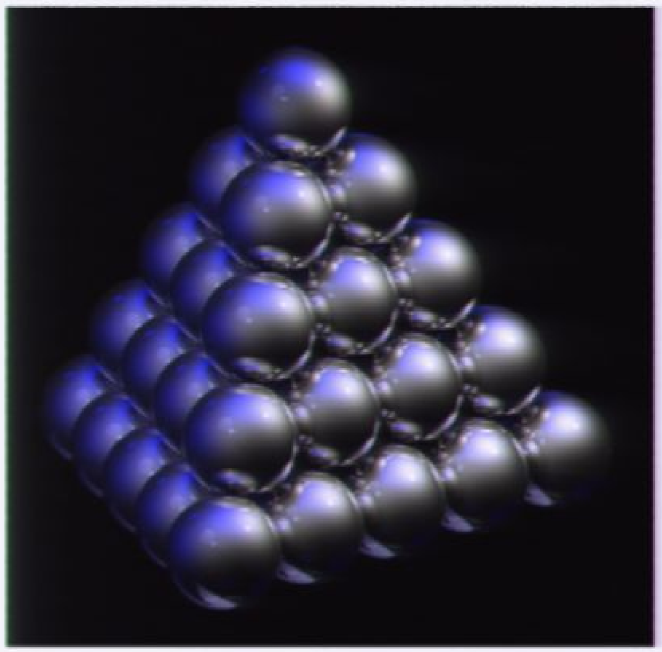

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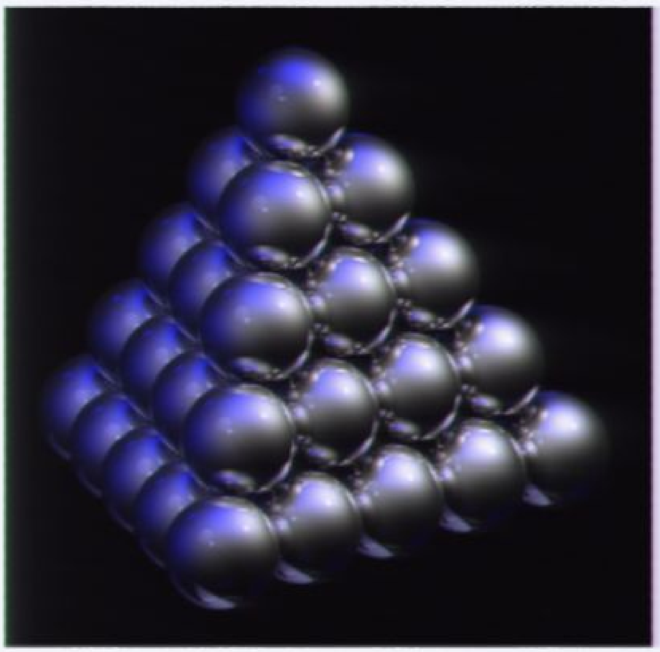

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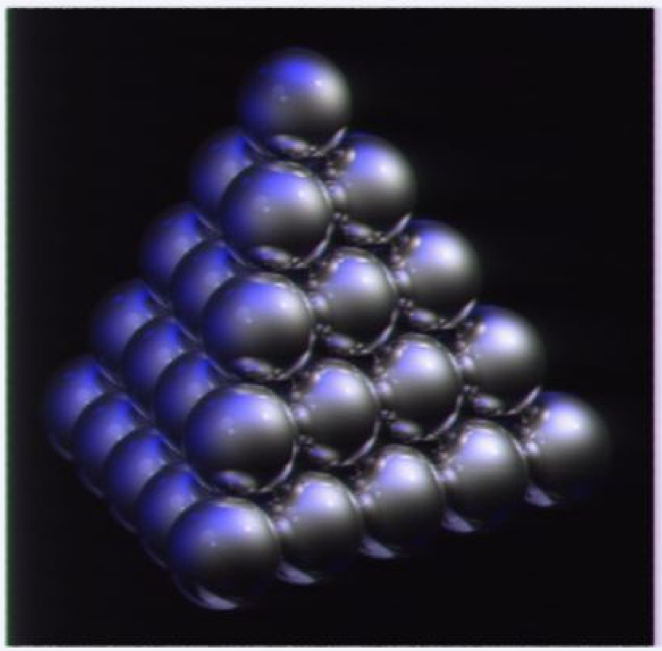

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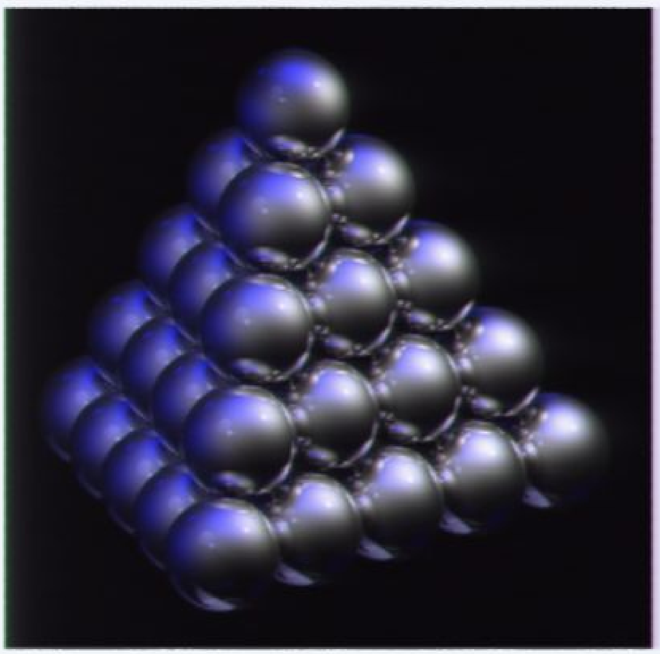

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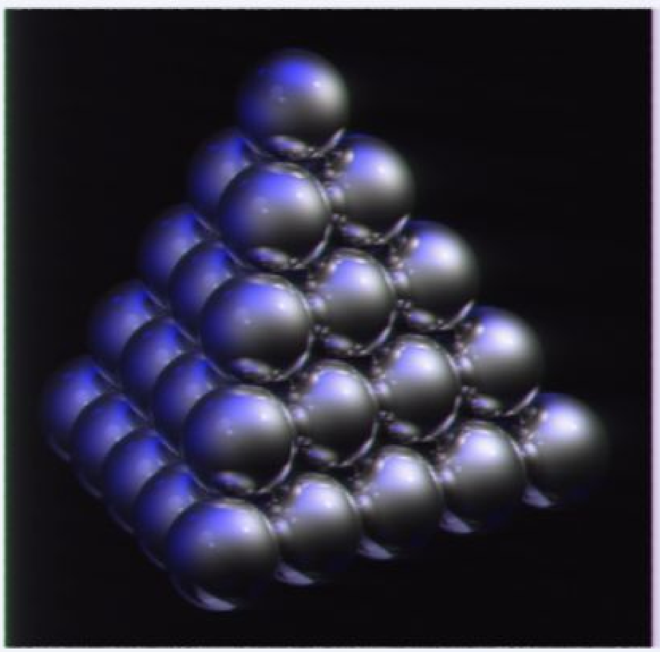

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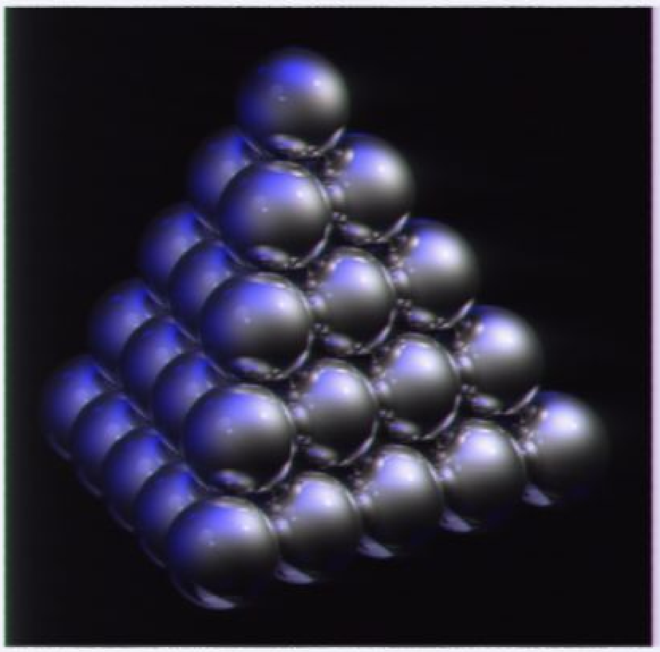

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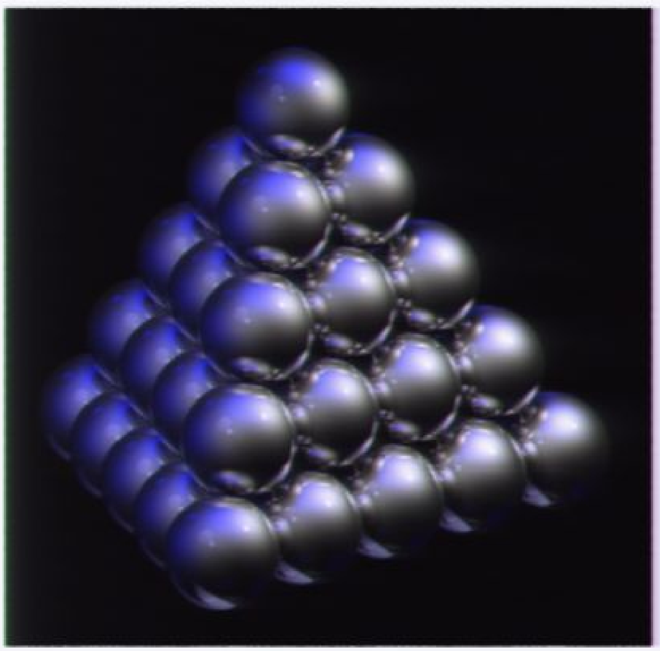

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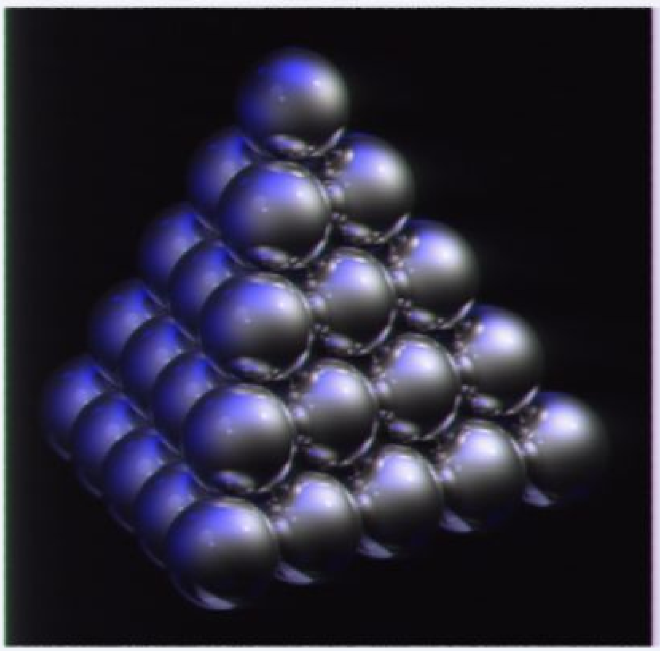

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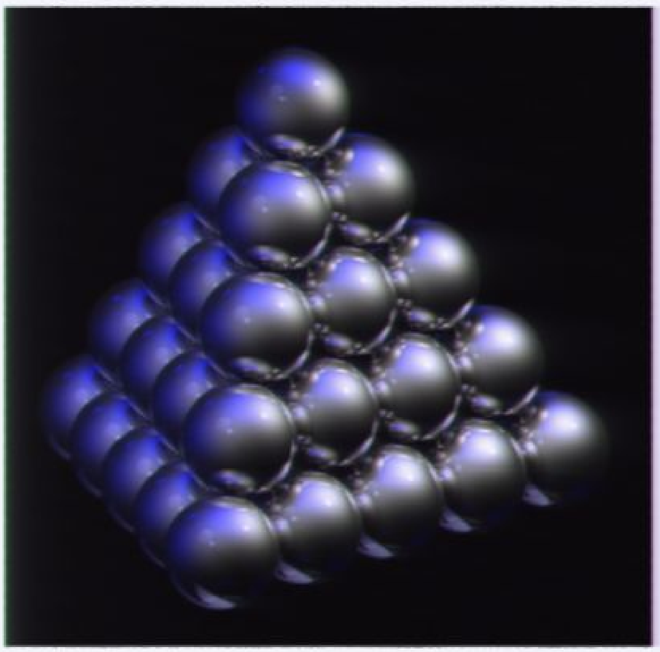

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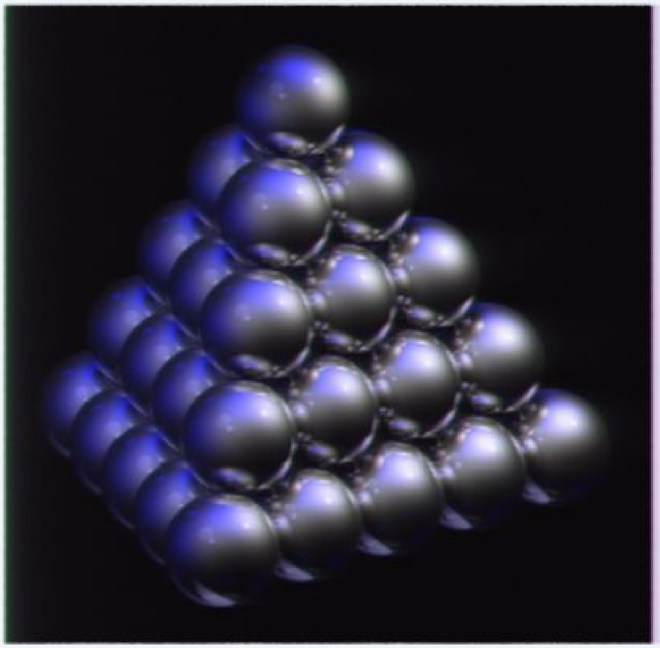

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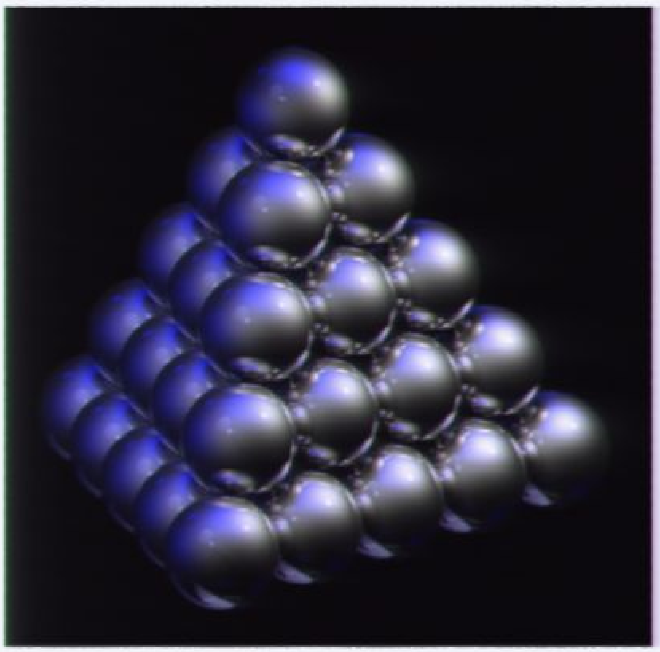

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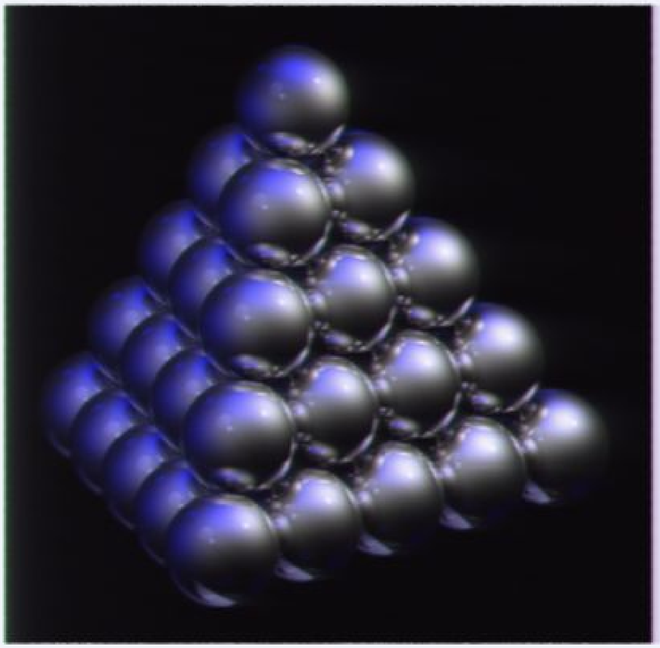

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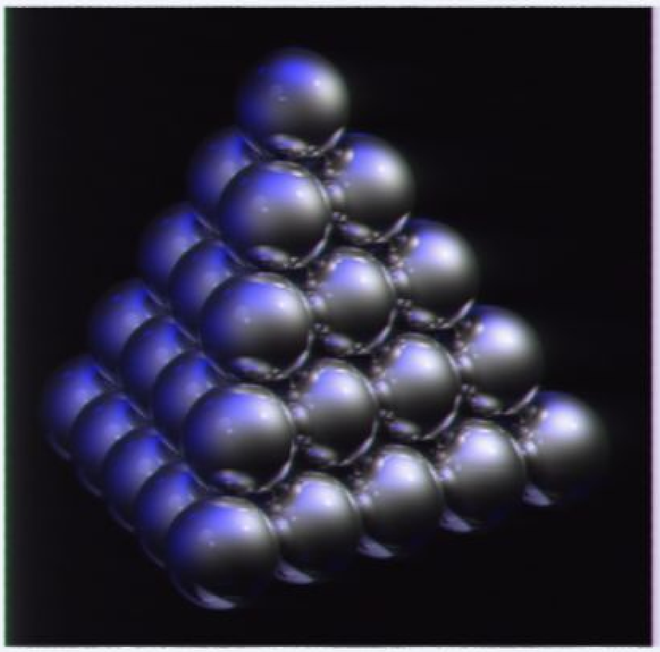

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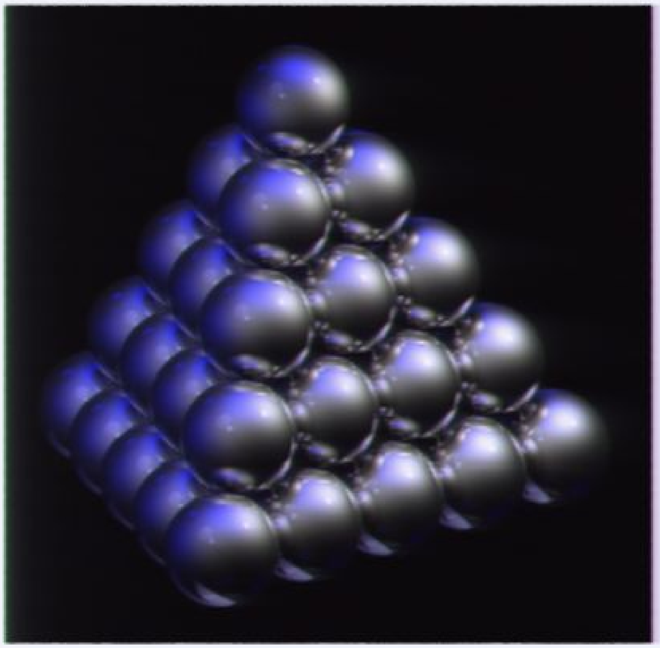

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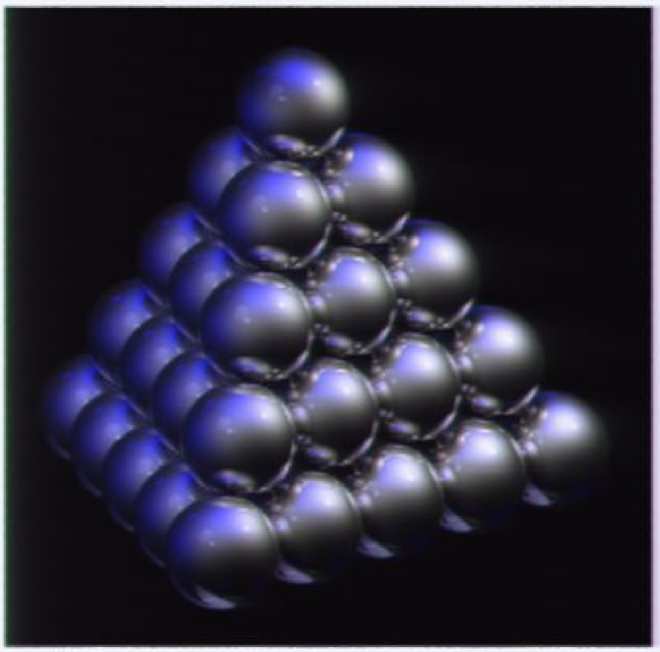

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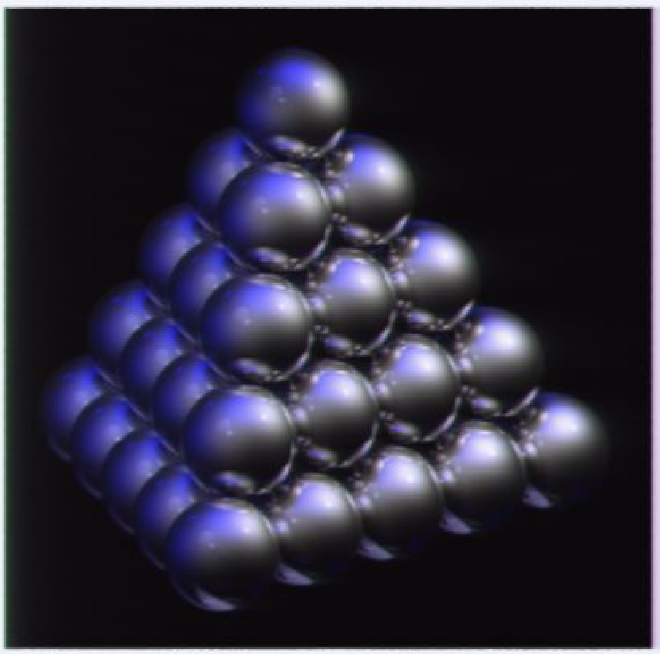

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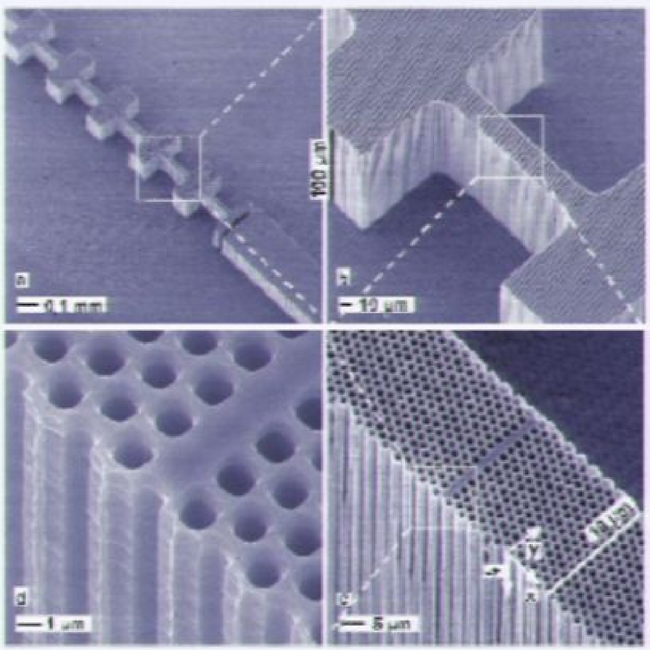

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crystals which are composed of periodic dielectric or metallo-dielectric nanostructures that affect the propagation of photons

Concept of Photonic Crystal

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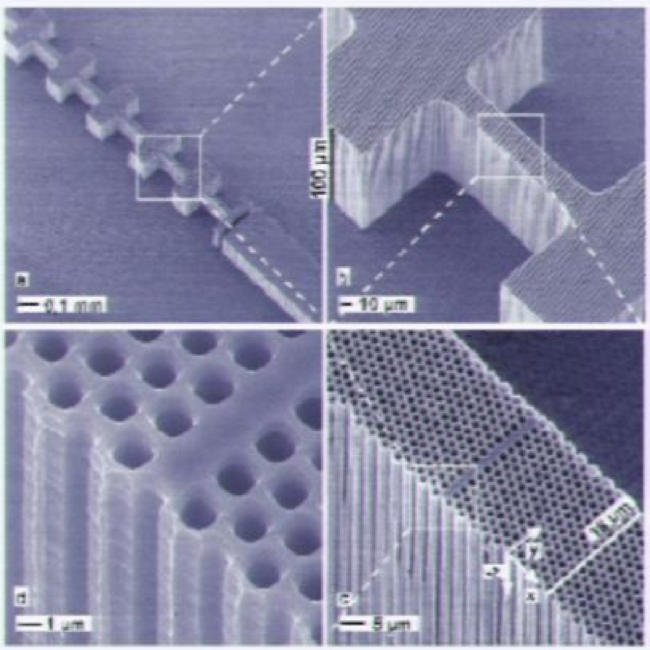

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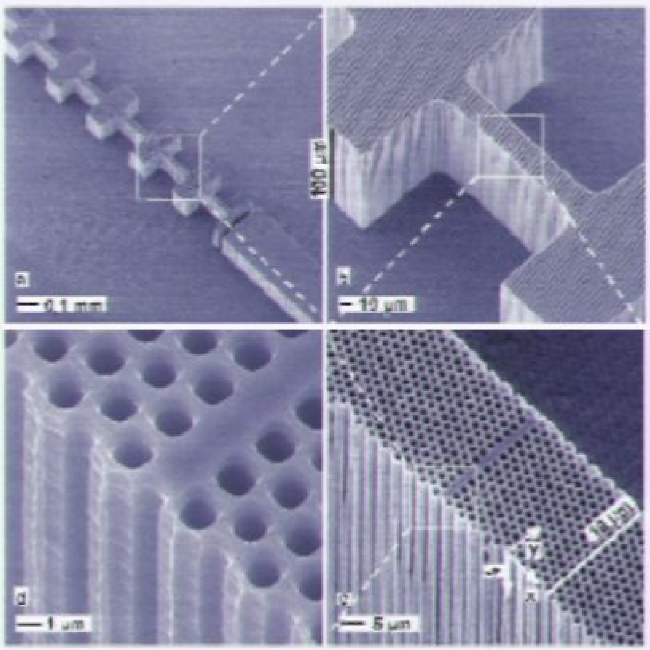

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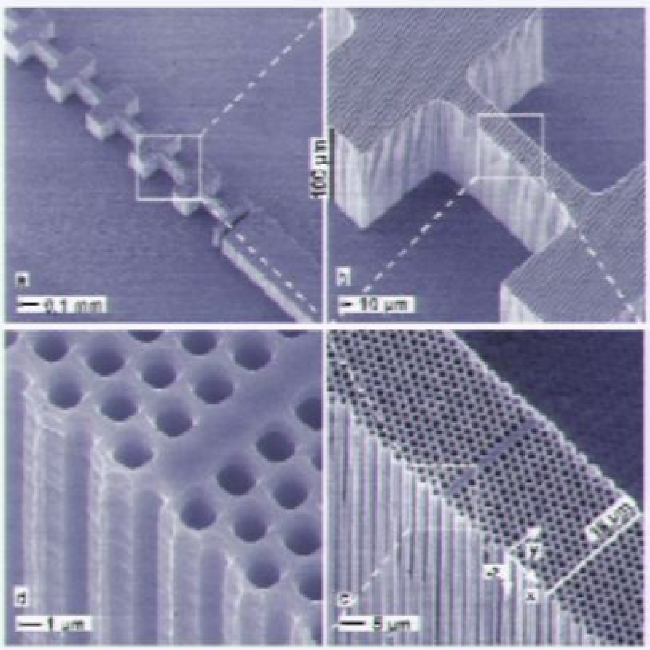

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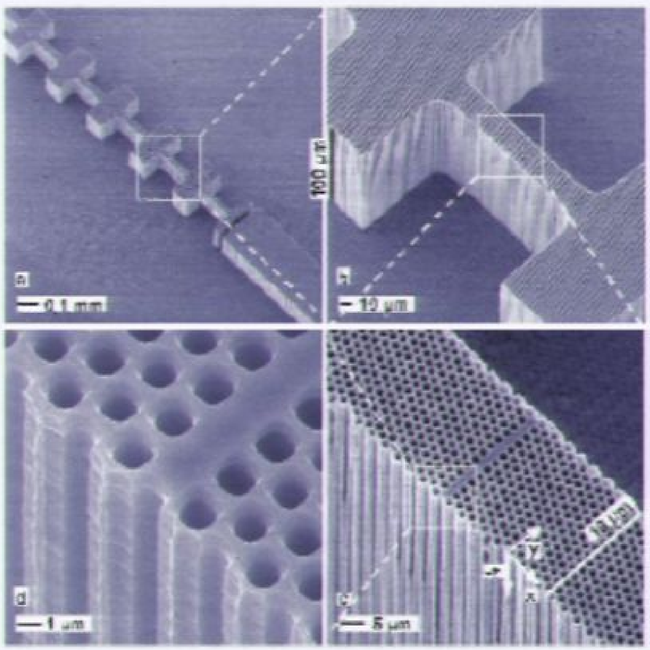

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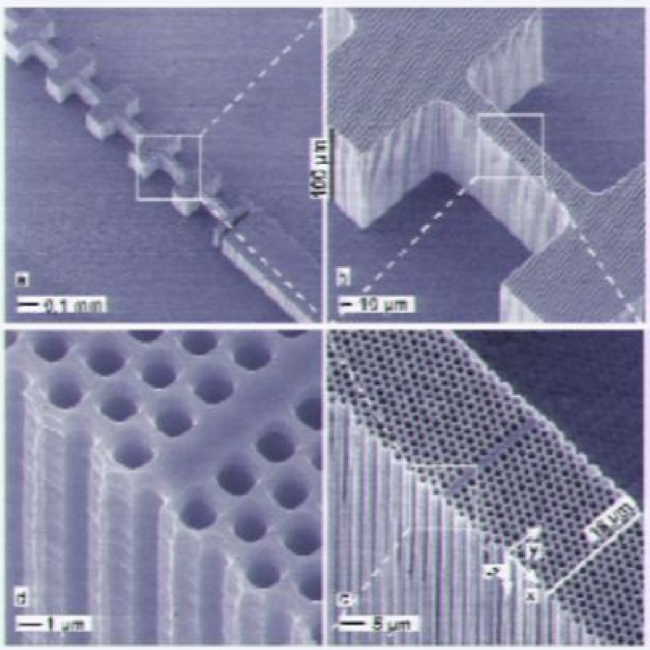

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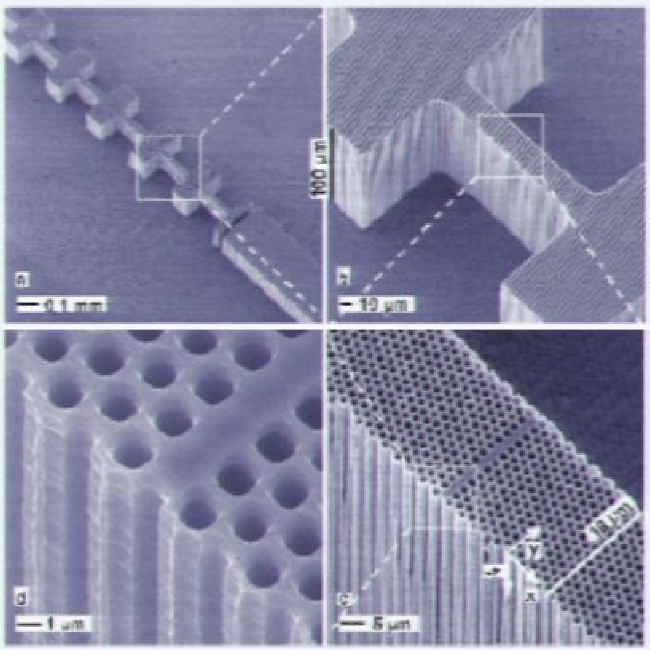

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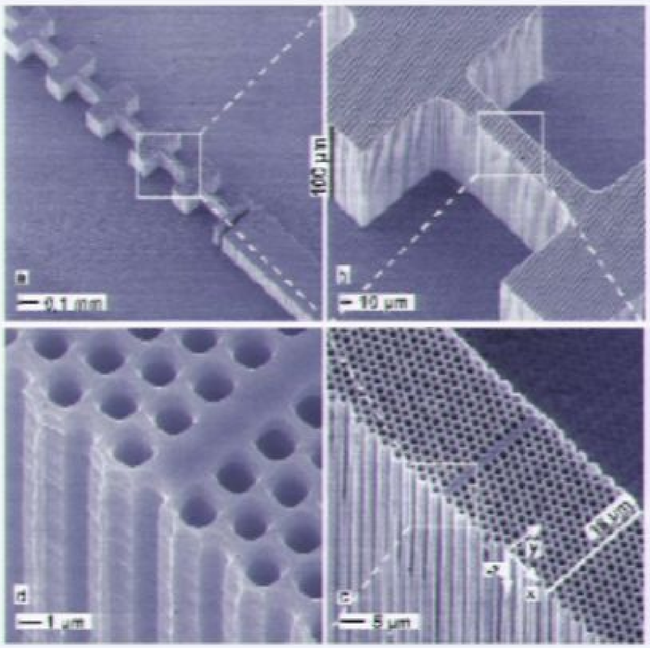

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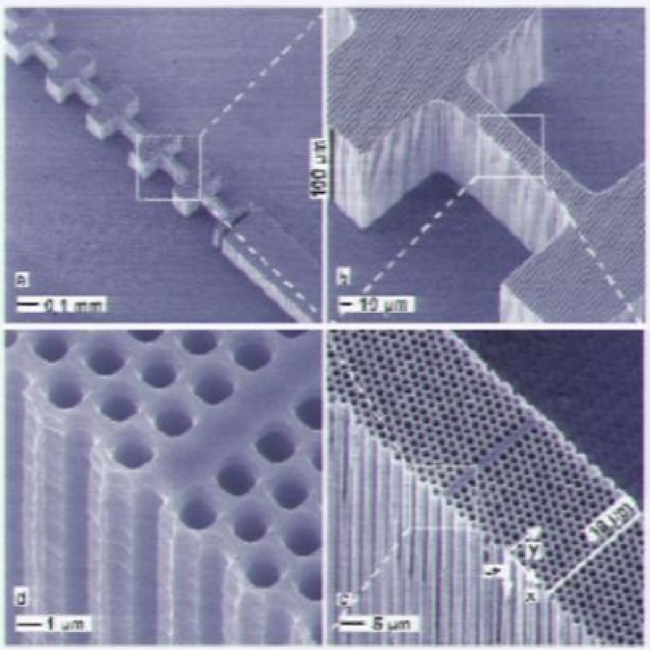

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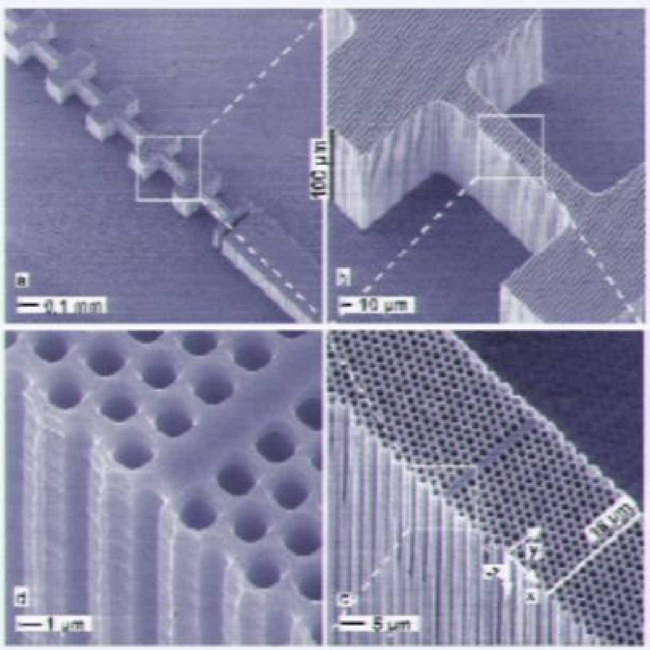

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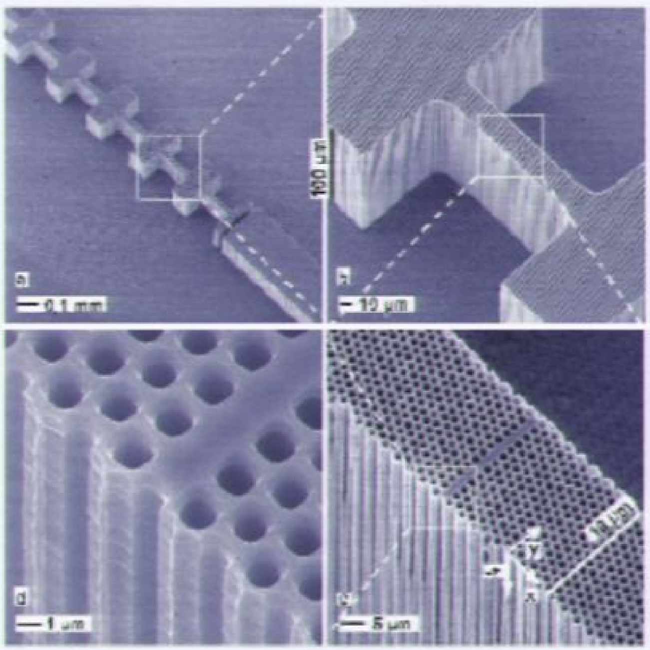

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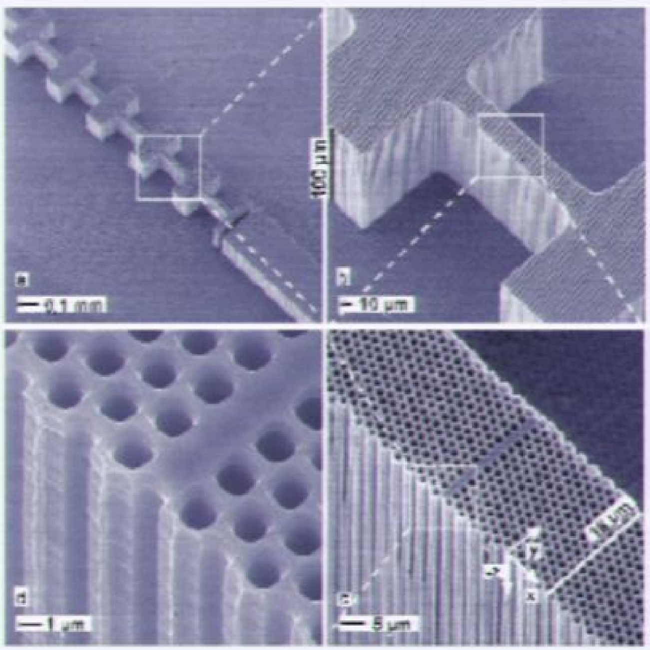

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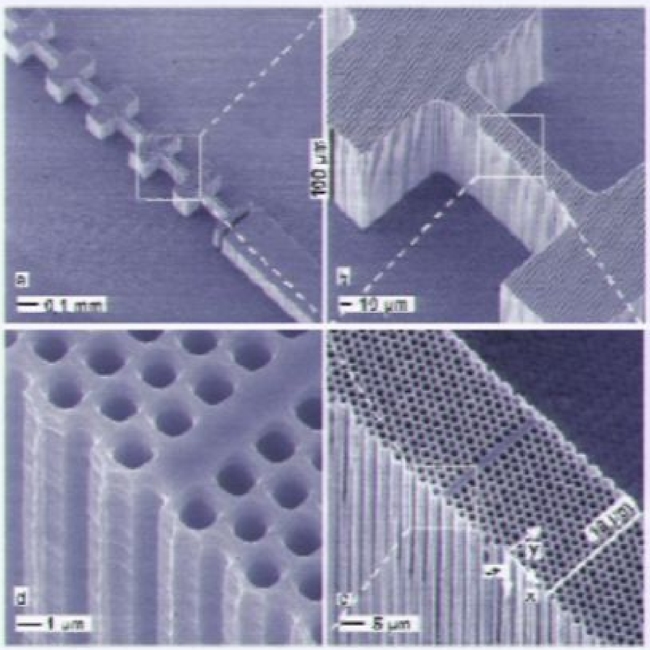

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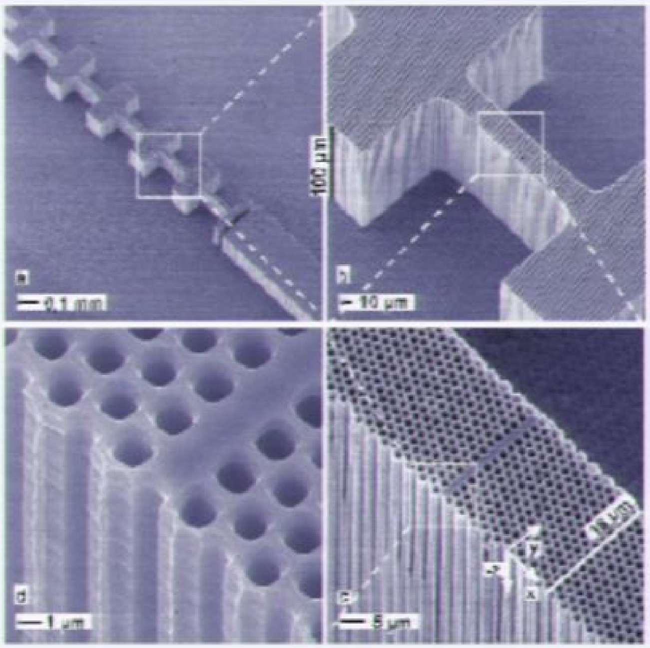

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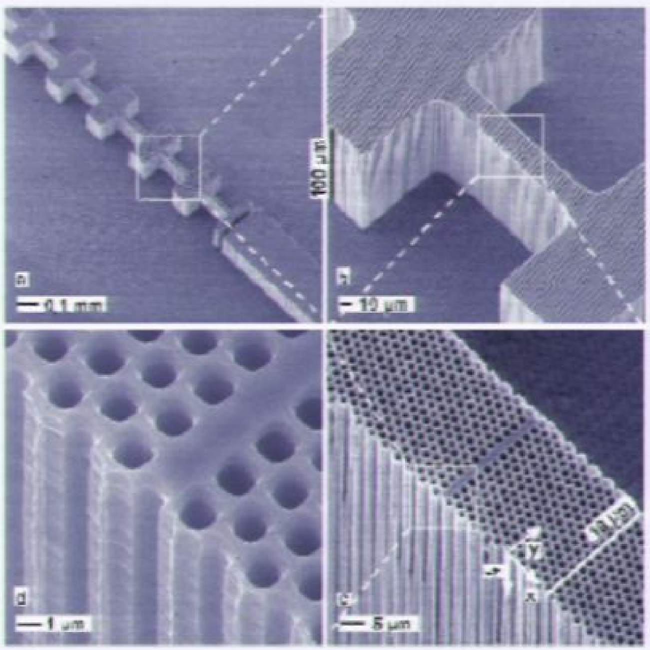

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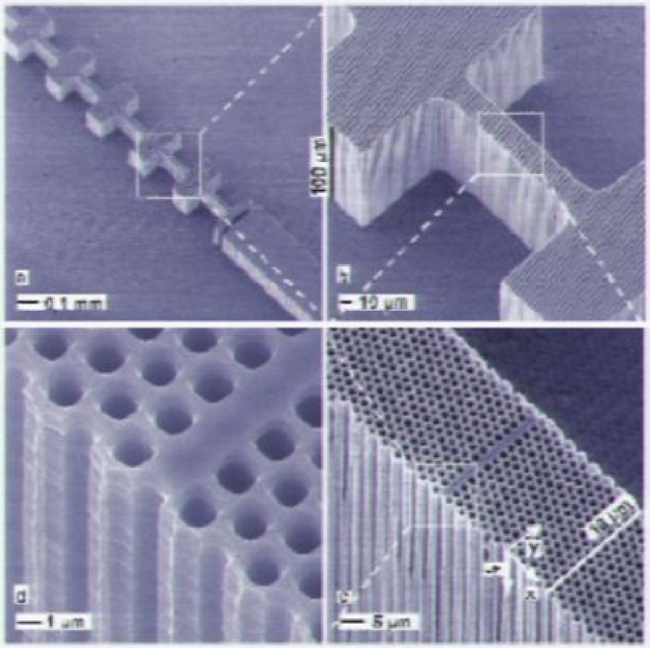

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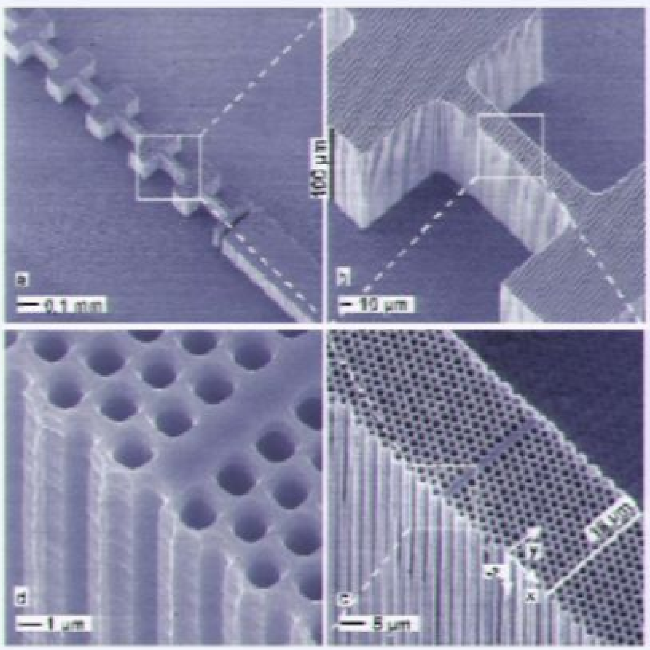

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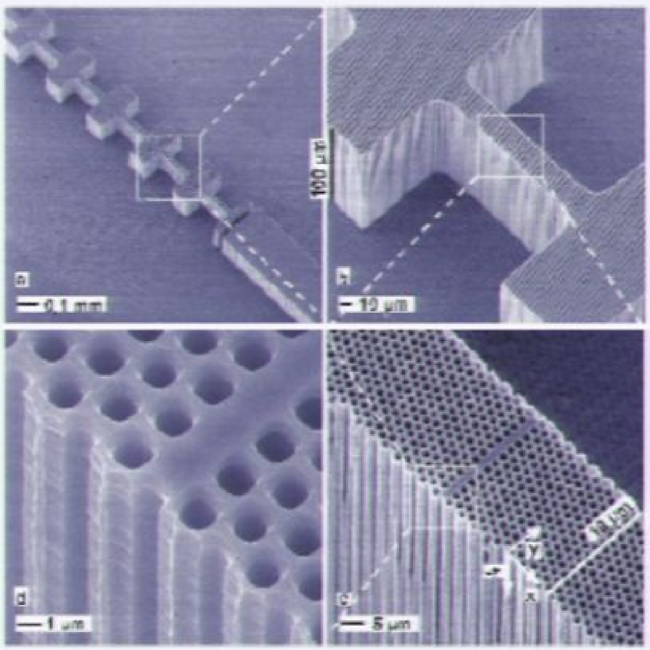

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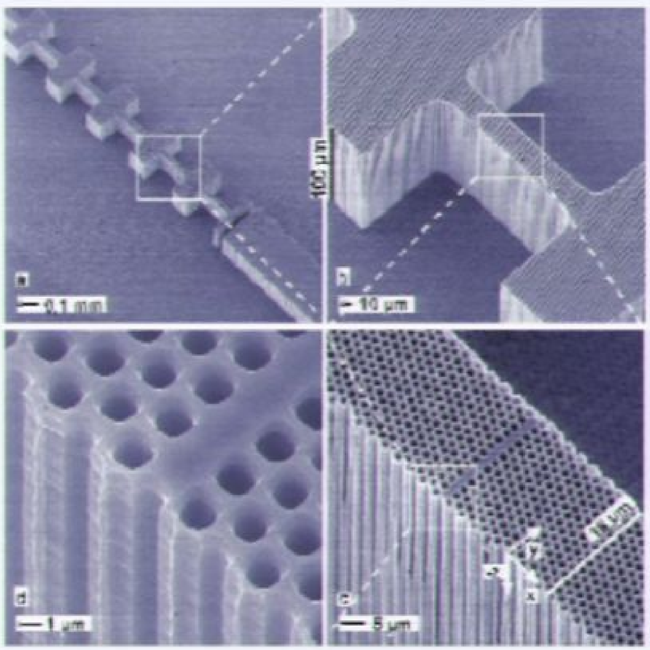

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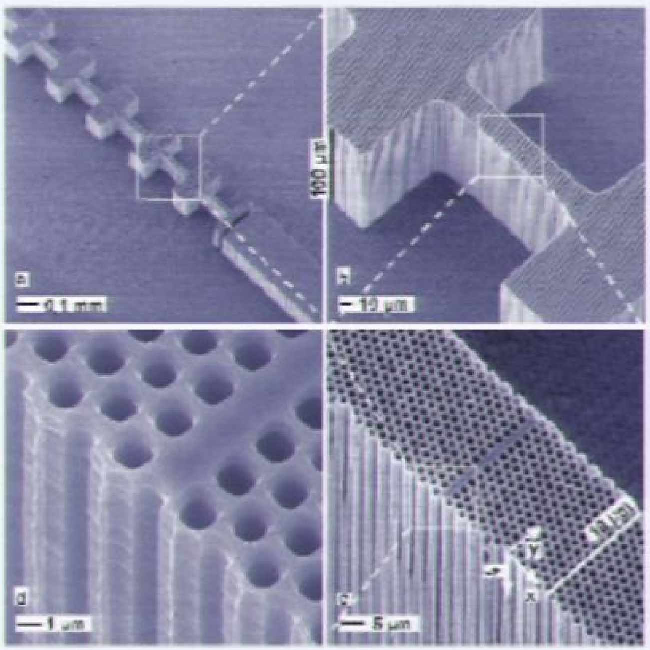

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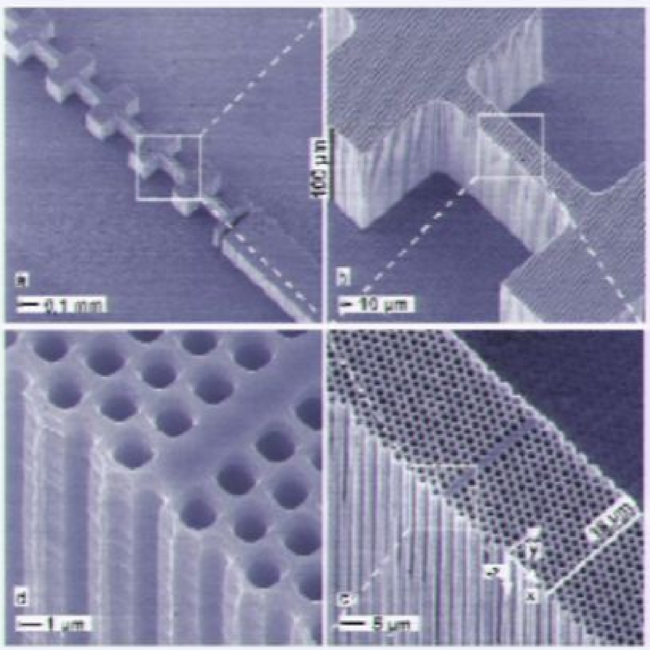

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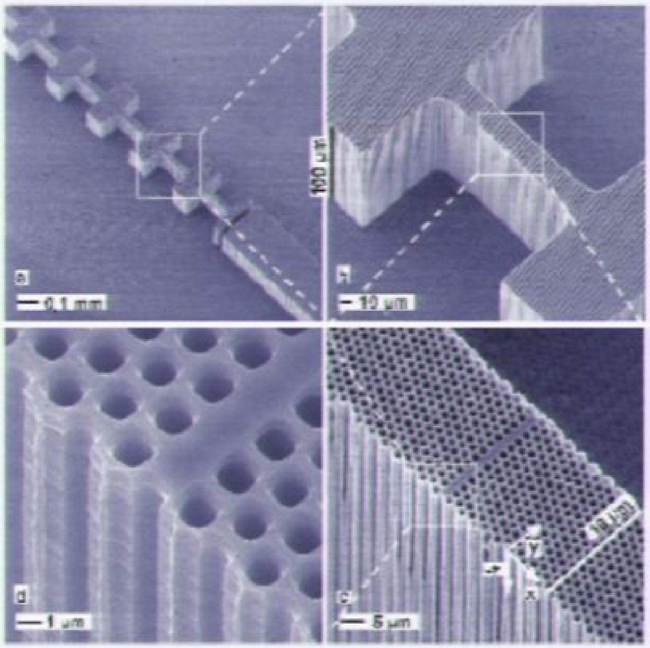

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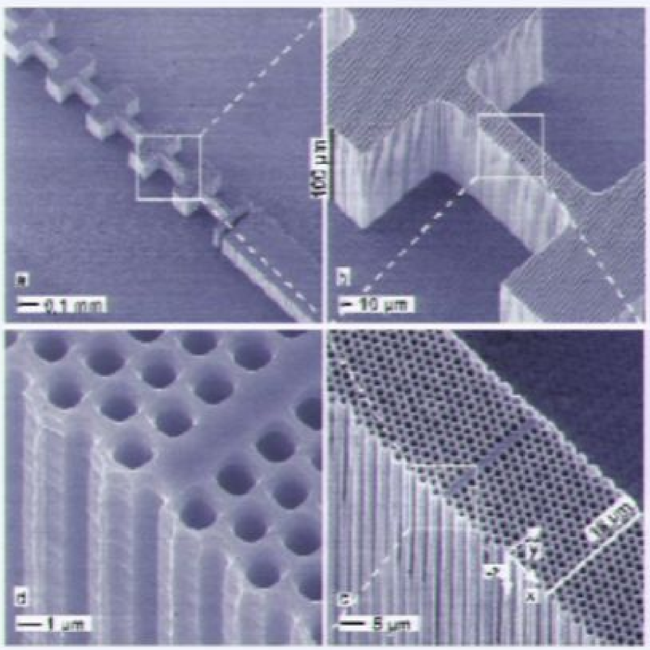

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similar to semiconductors

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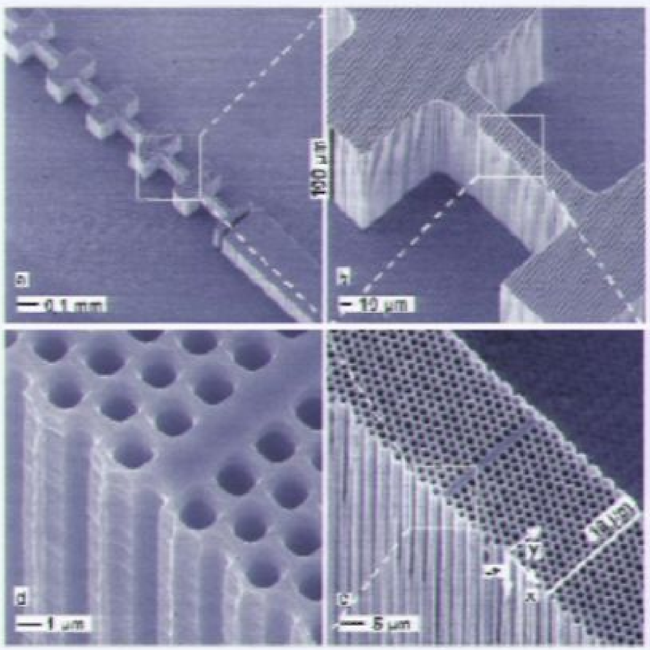

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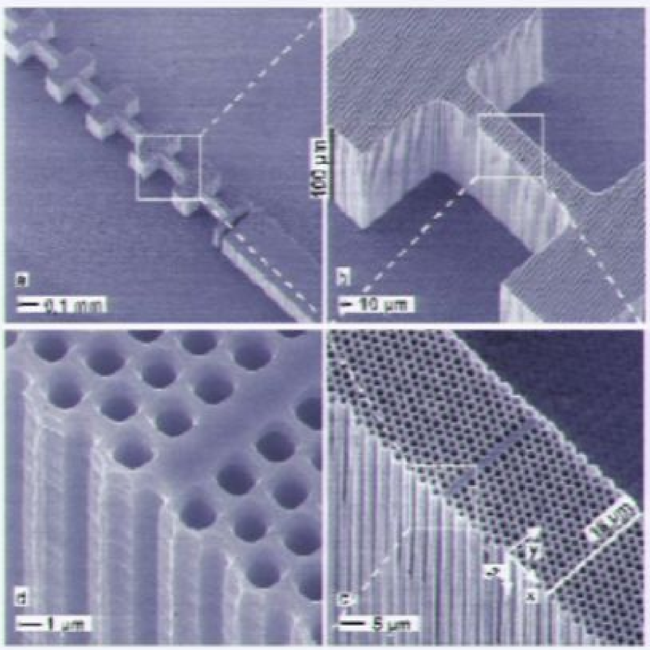

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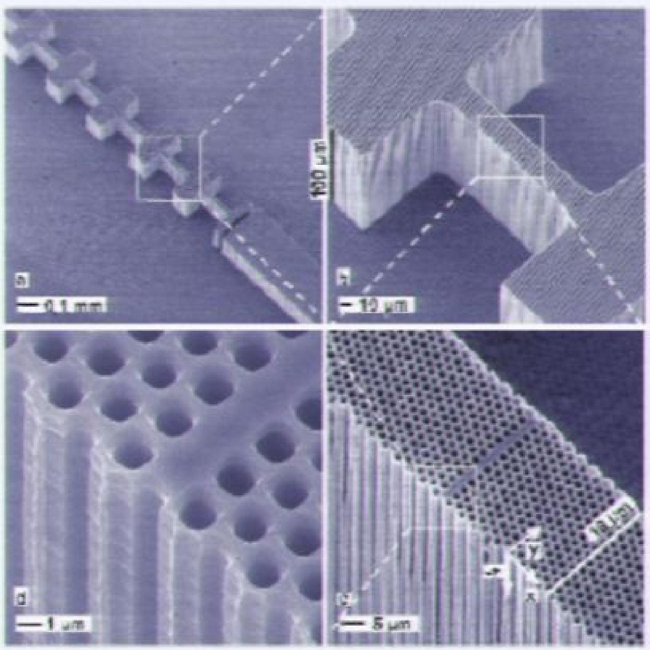

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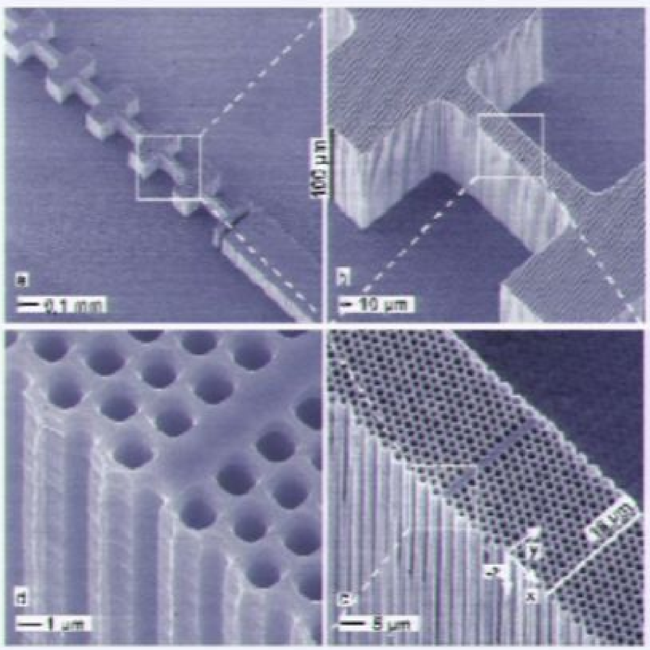

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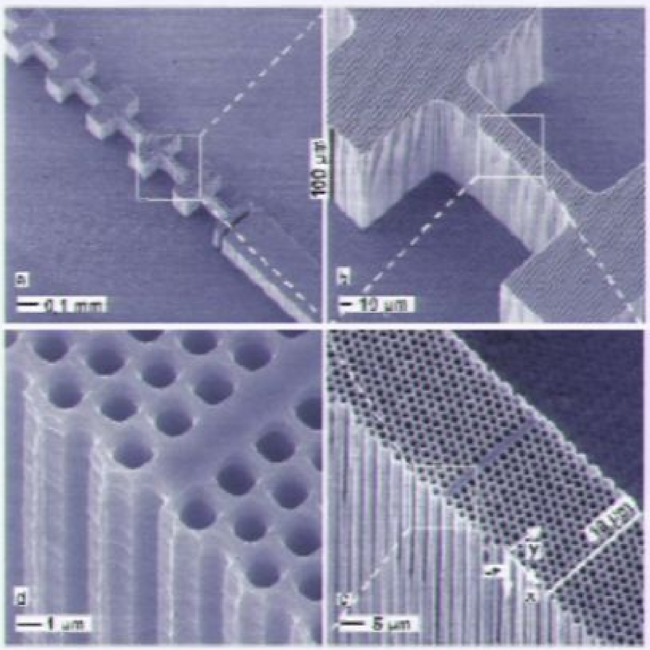

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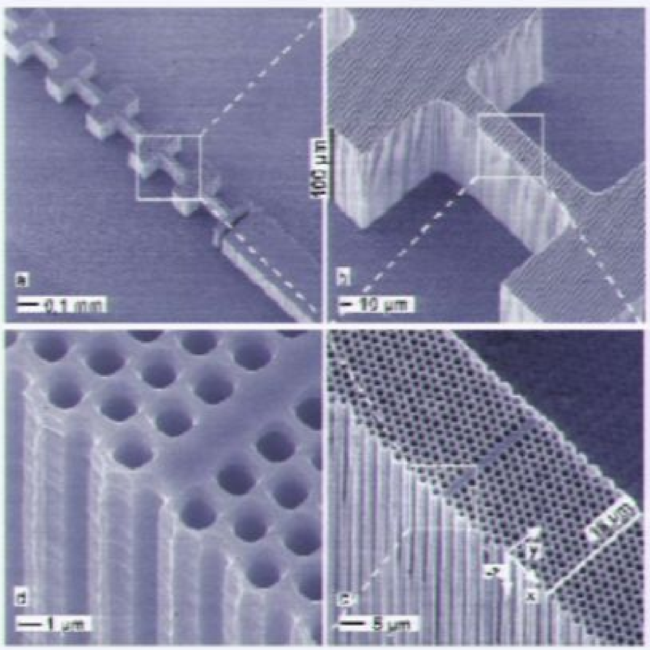

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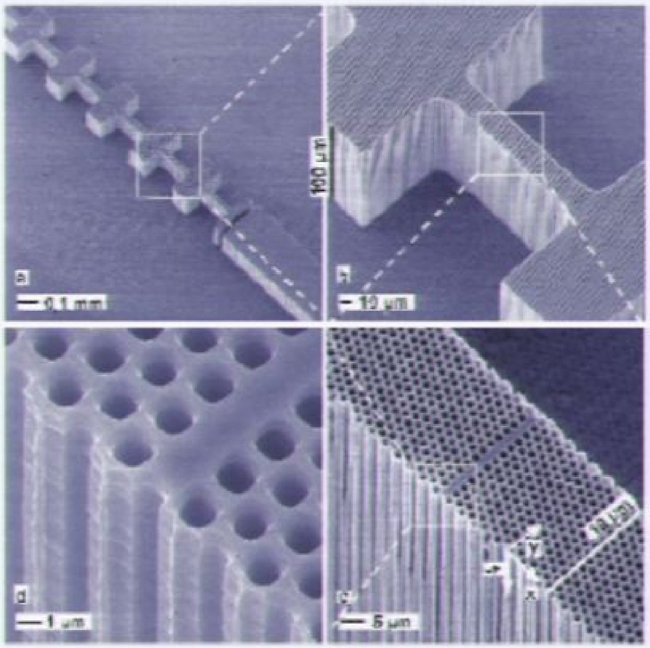

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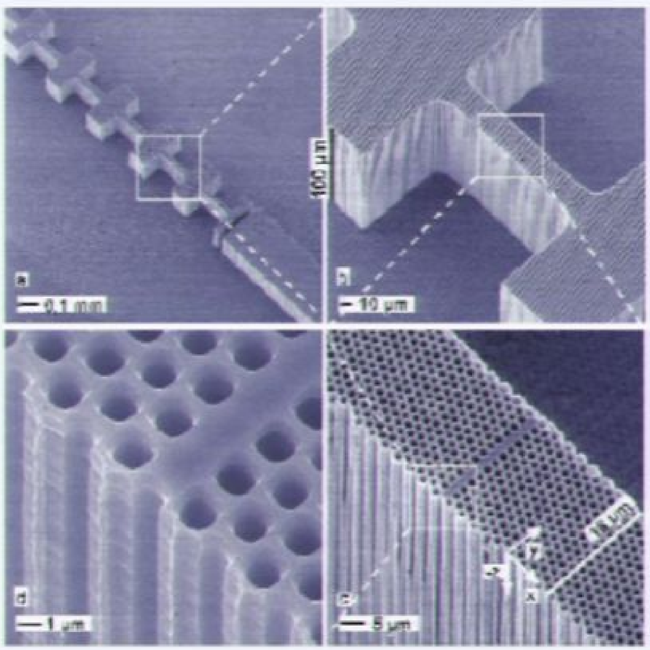

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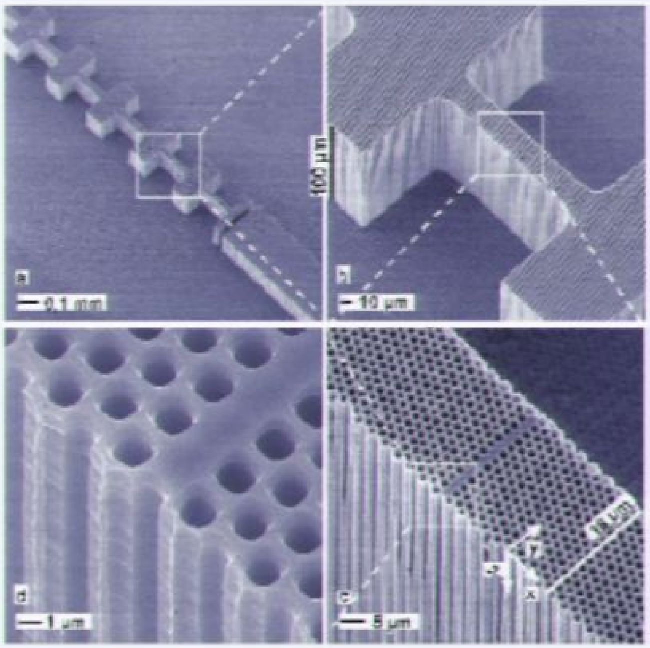

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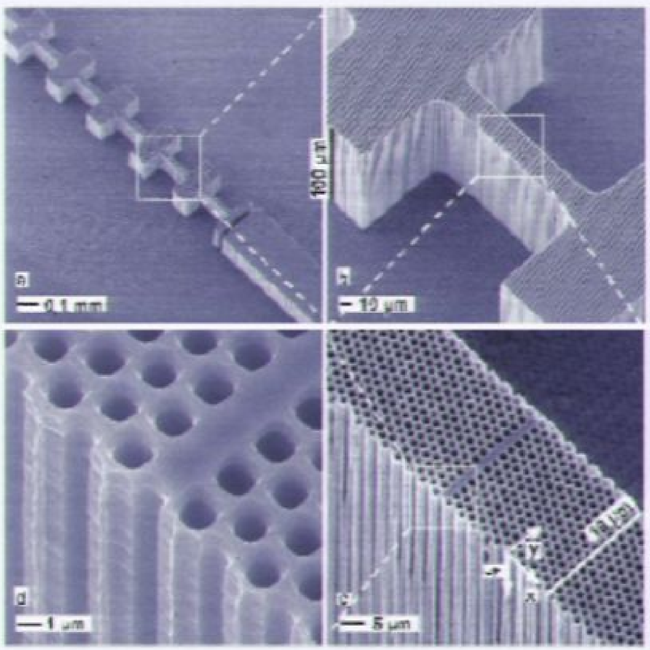

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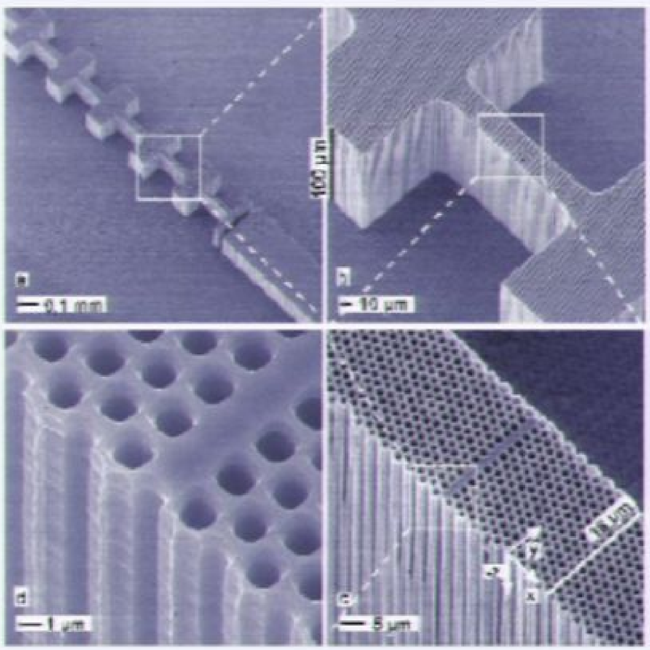
similar to semiconductors

Concept of Photonic Crystal

Microstructure



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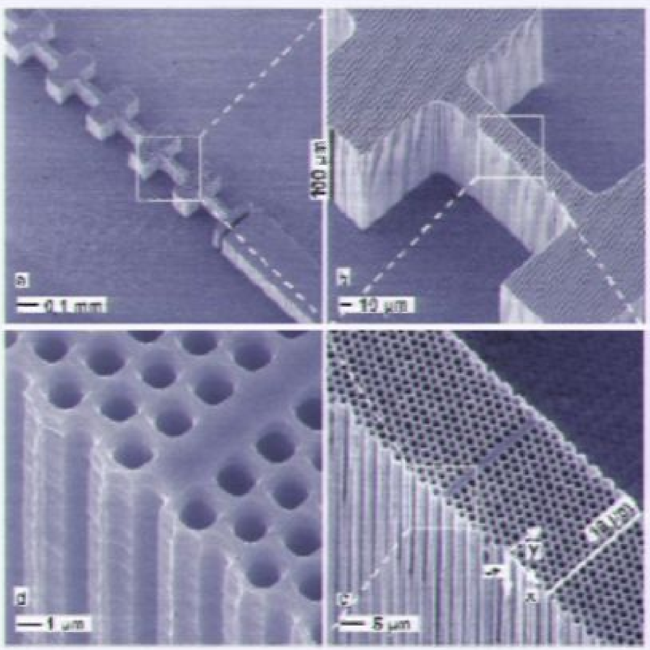

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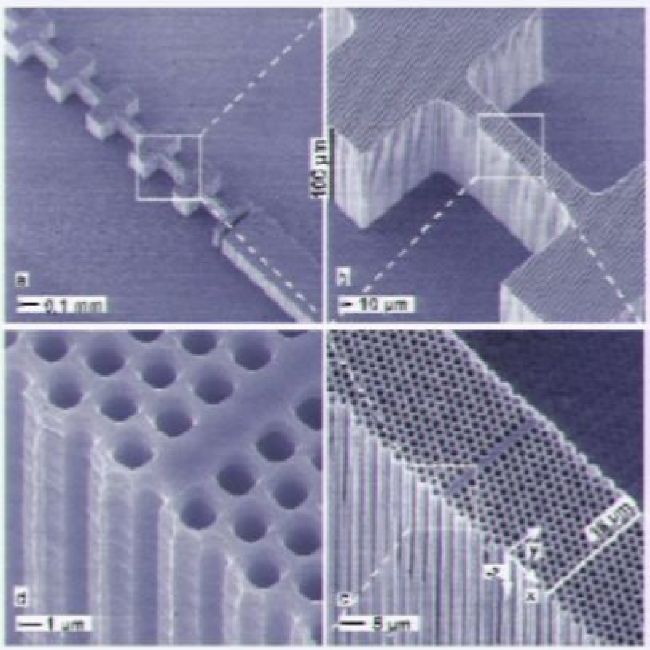

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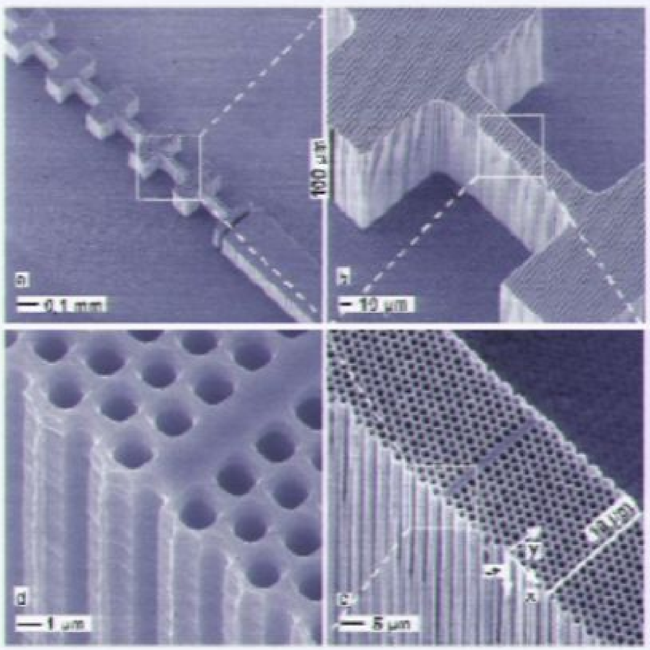

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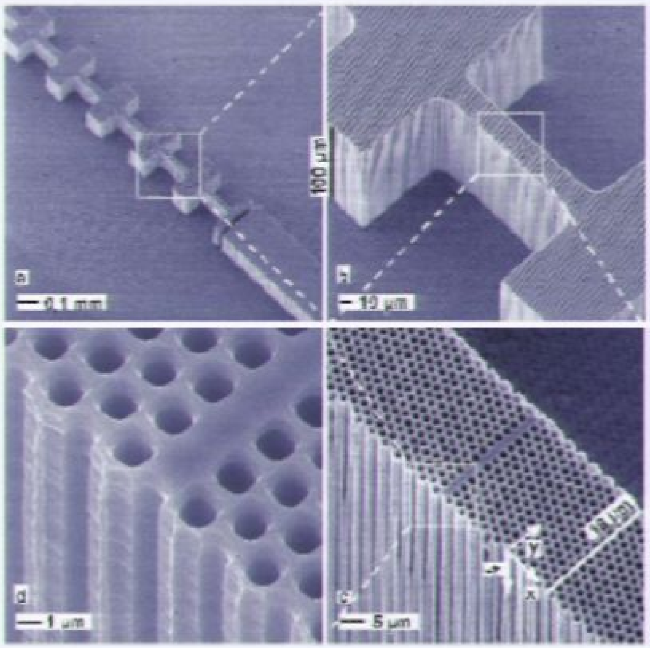

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Essential Property

Regularly repeating internal regions

Concept of Photonic Crystal

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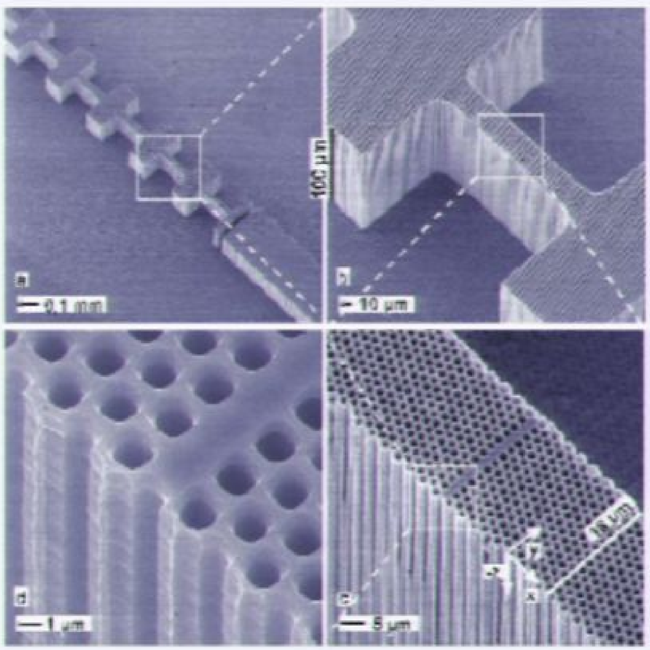

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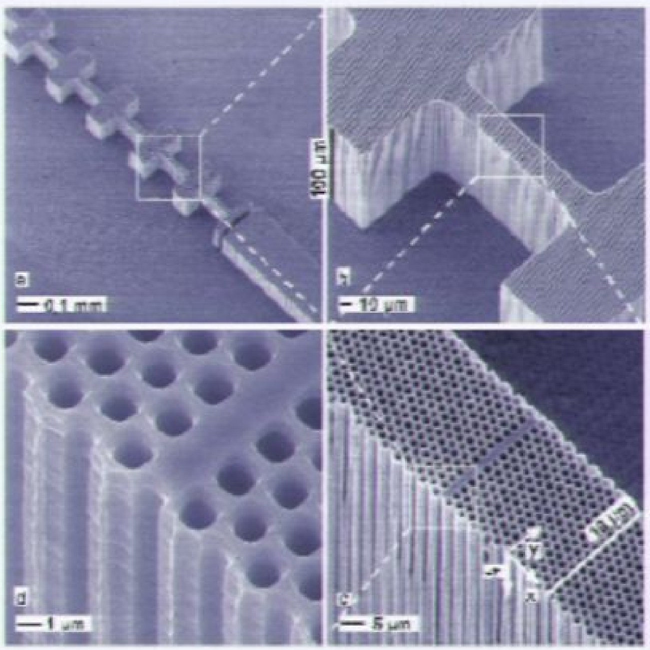

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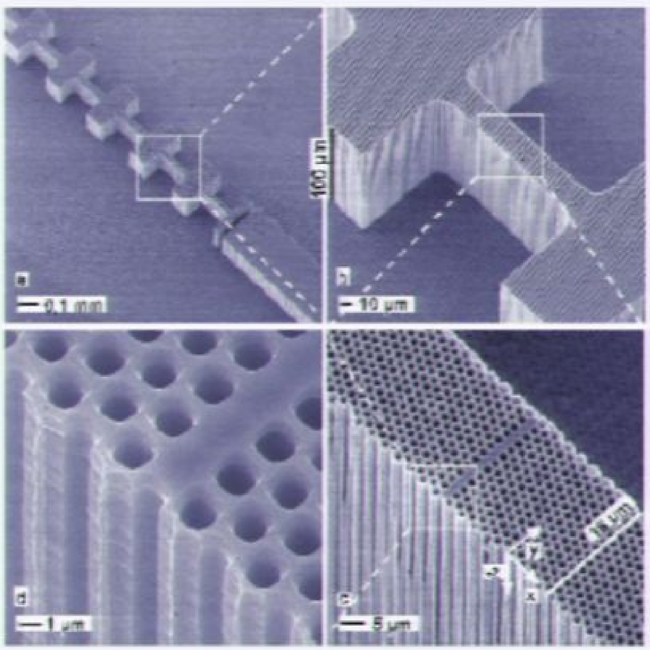

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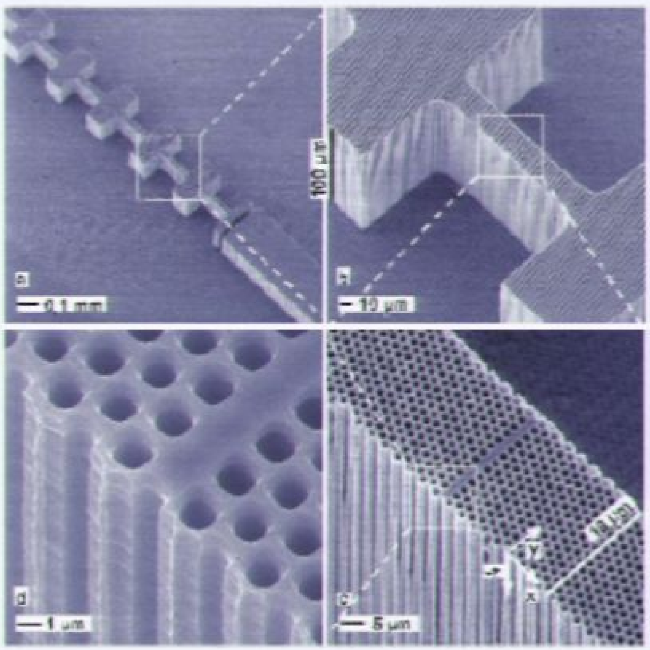

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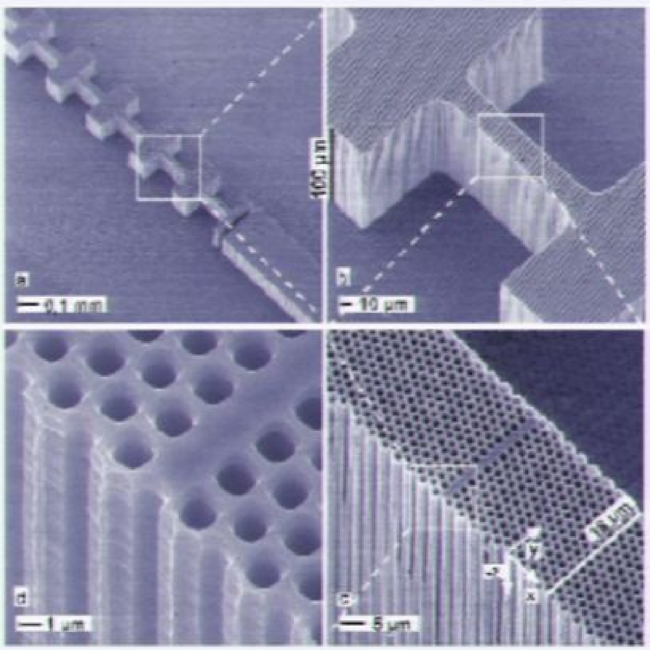

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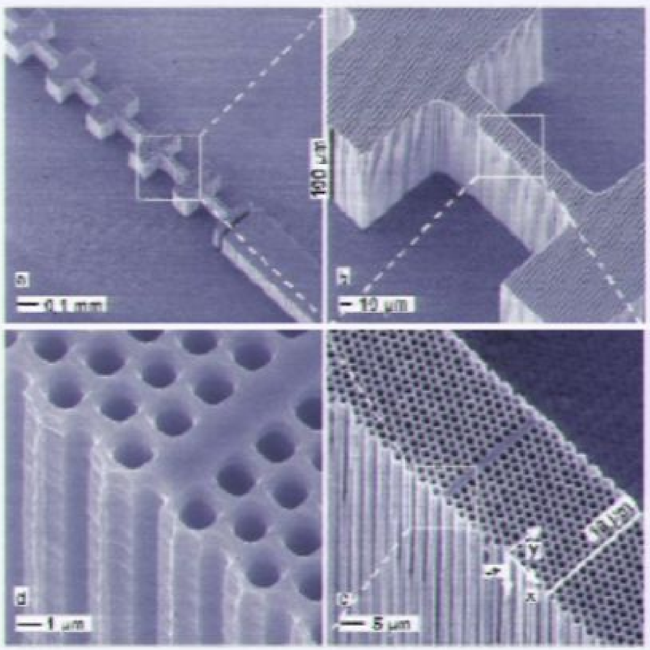

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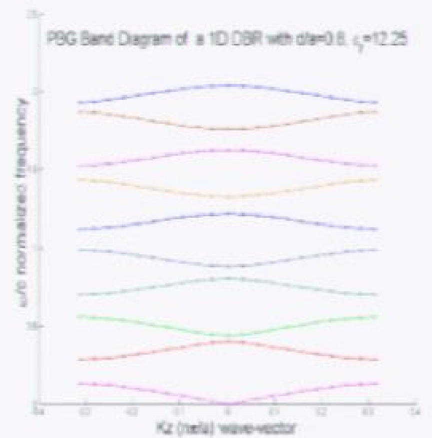
Design Your Photonic Crystal

Keypoint:PBG



Location and Size of PBG

Design Your Photonic Crystal

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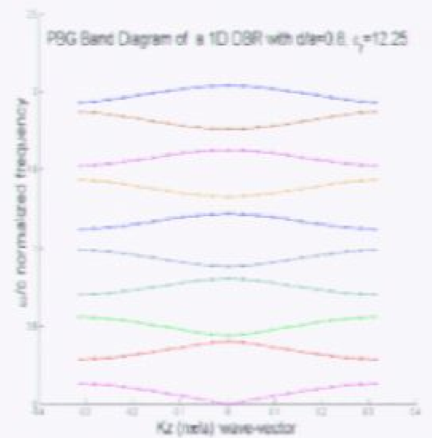

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Plane Wave Expansion Methods

Finite Difference Time Domain

Order-N Spectral Method

KKR Method

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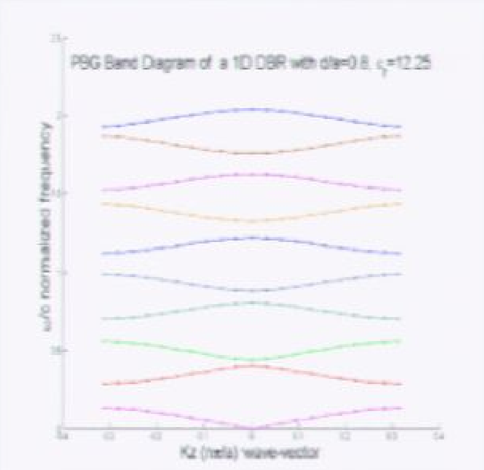

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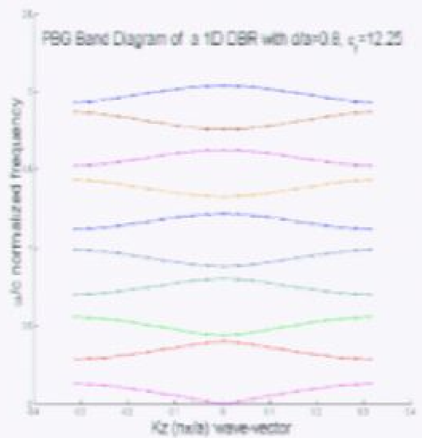

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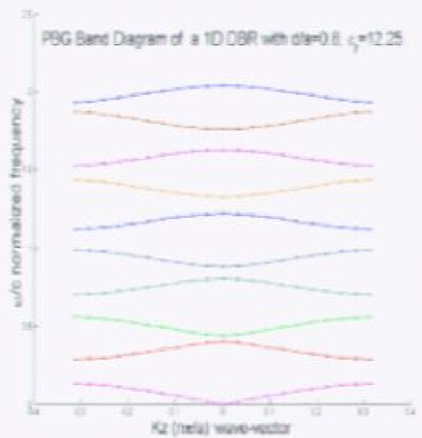

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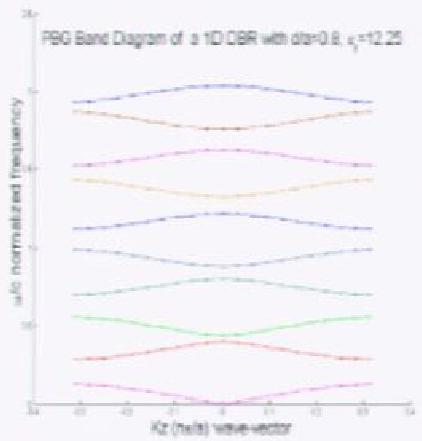

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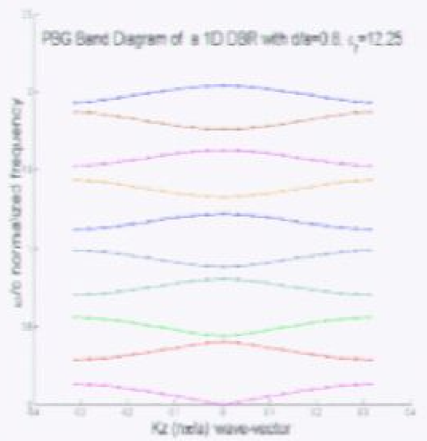

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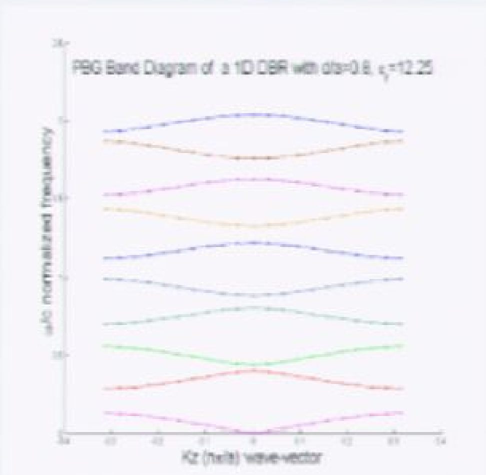

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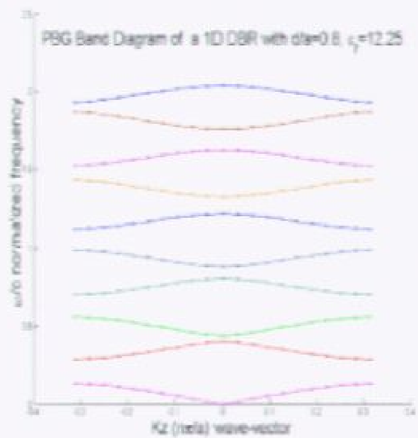

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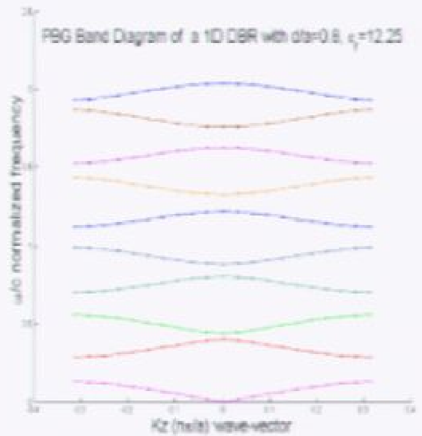

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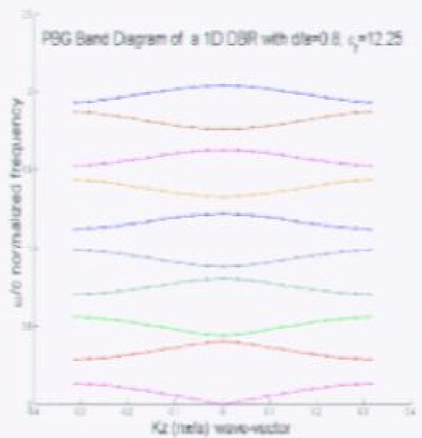

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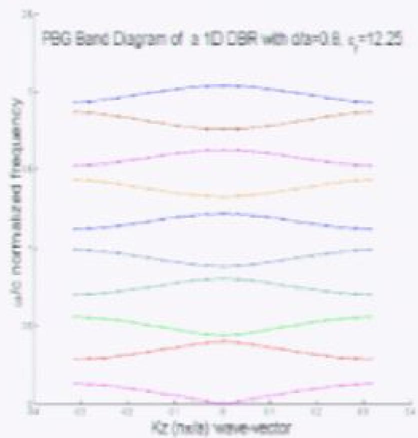

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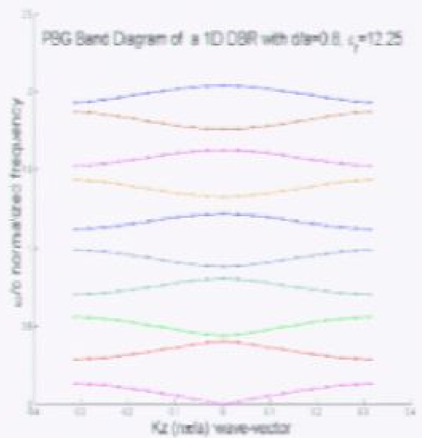

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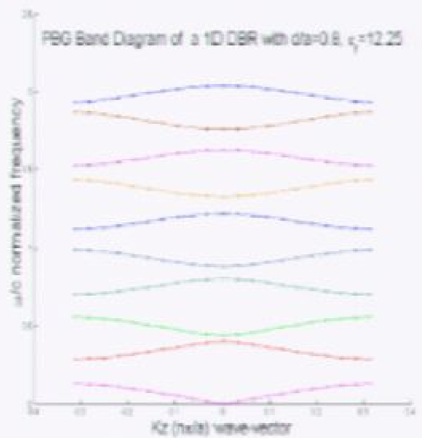

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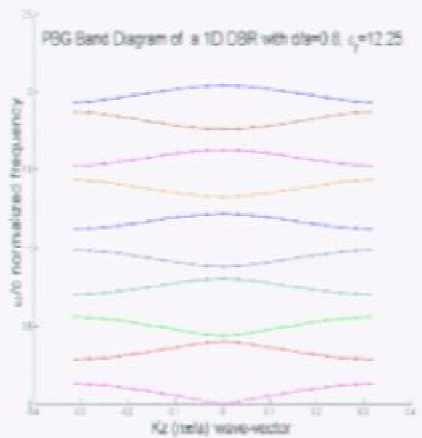

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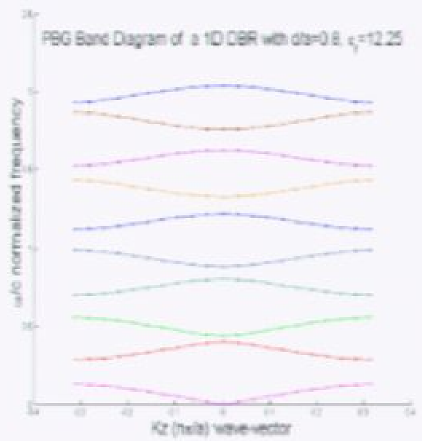

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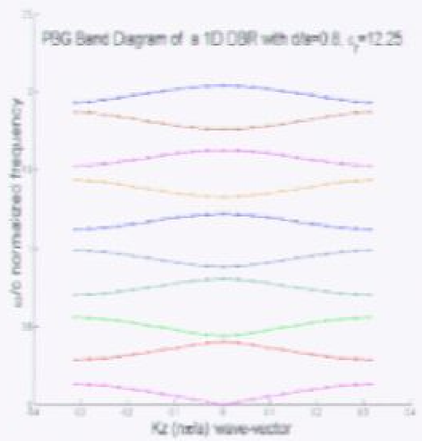

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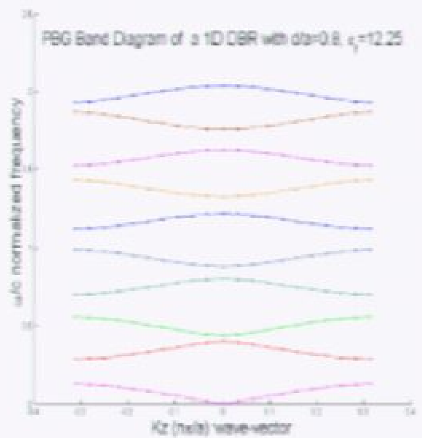

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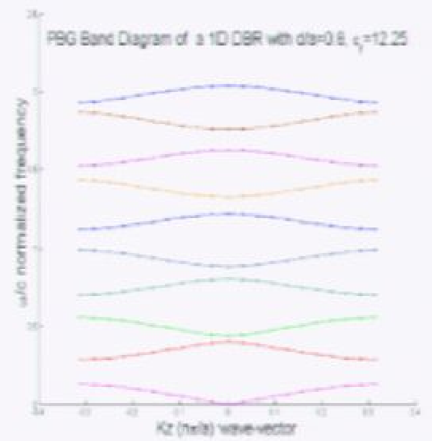

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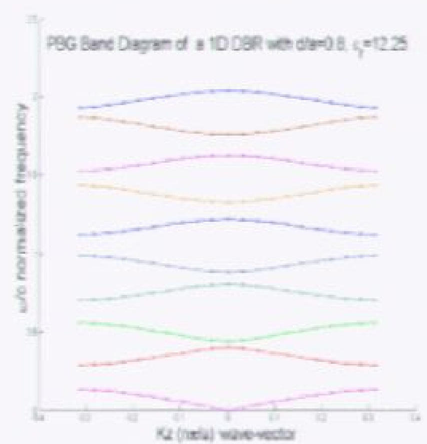

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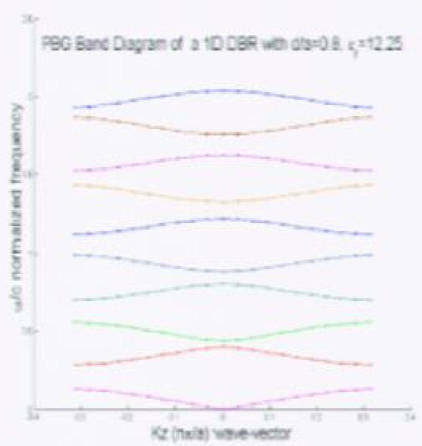

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3-D Photonic Crystal—Research, Optical computer

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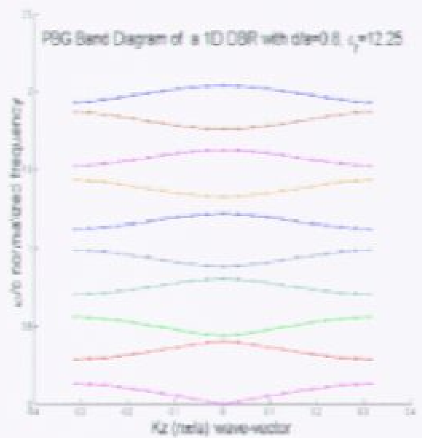

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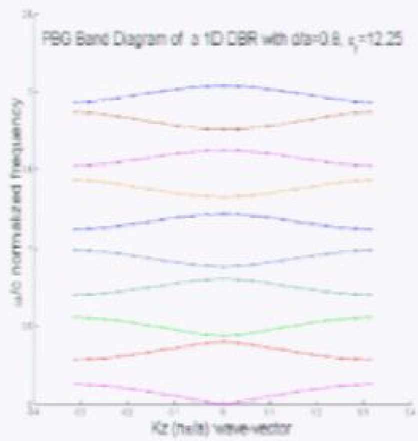

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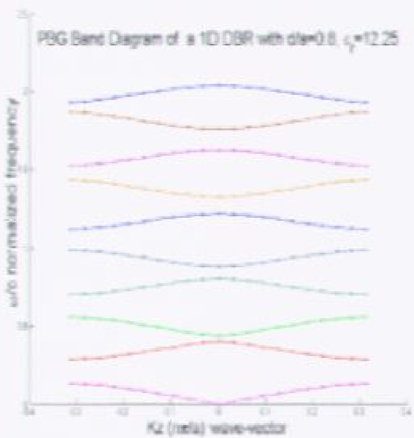

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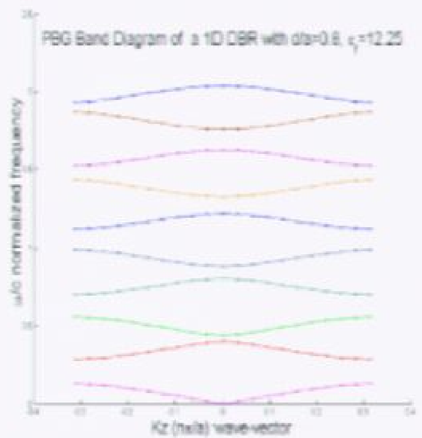

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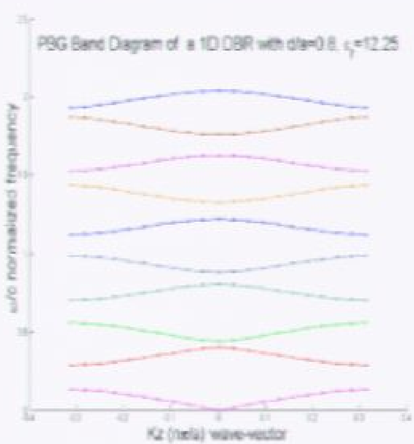

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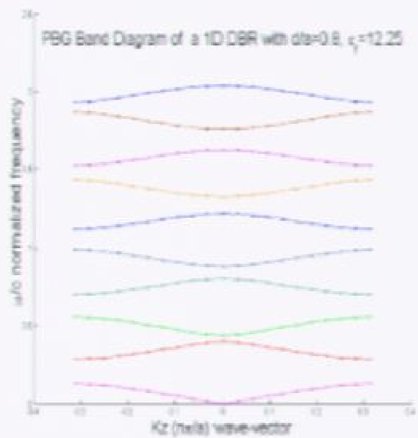

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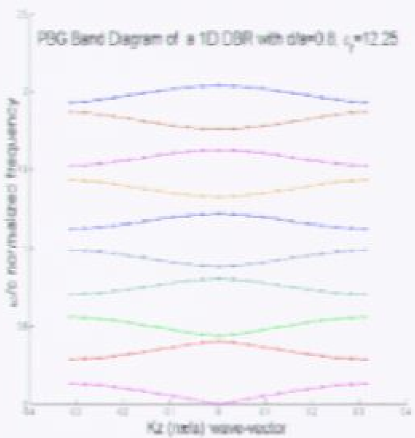

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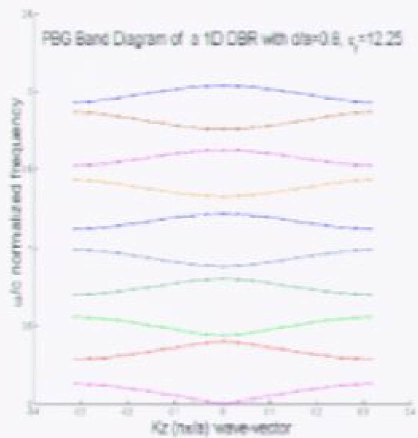

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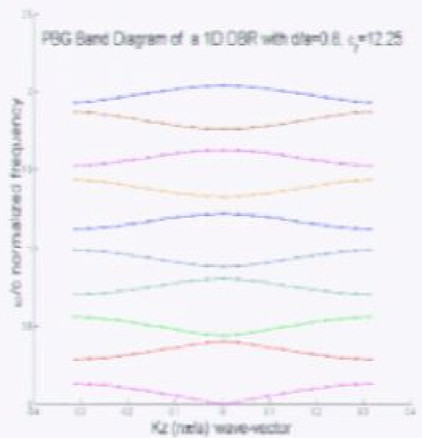

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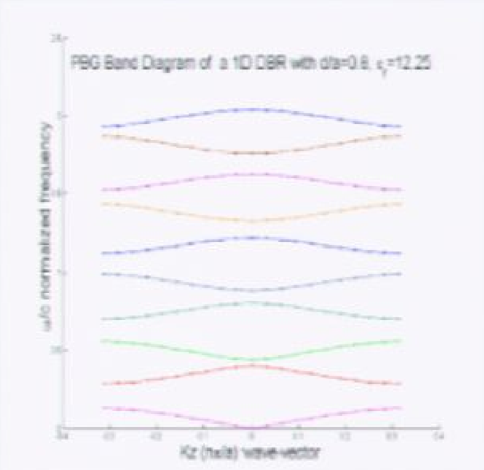

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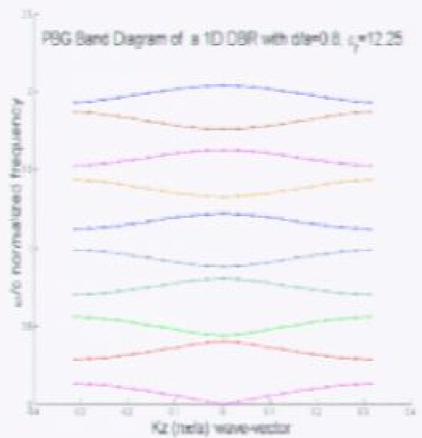

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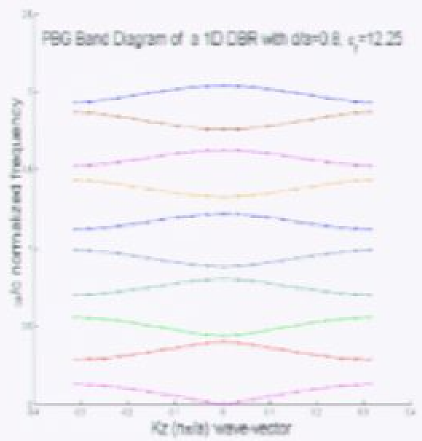

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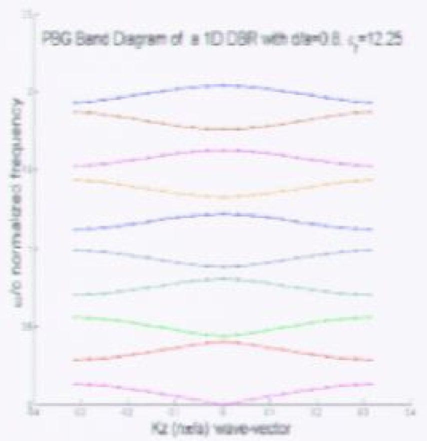

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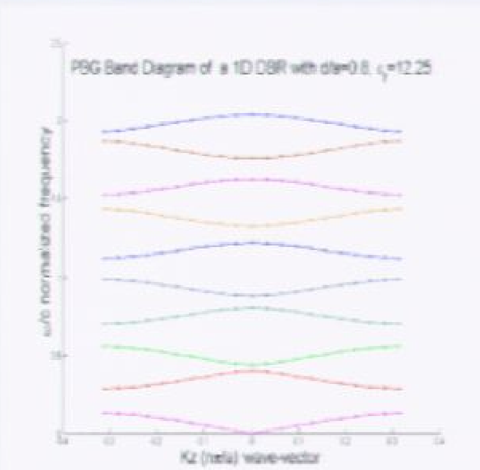

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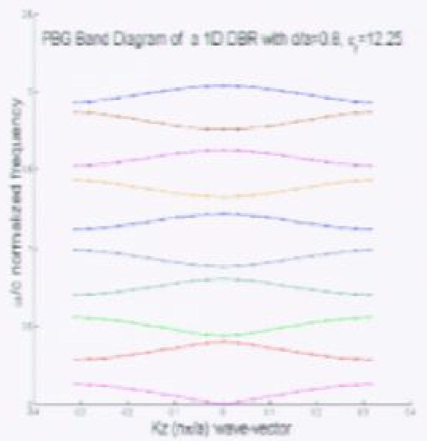

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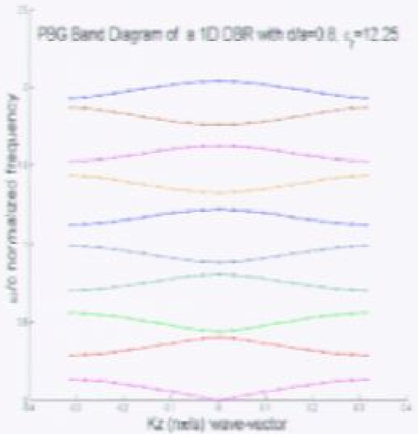

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Order-N Spectral Method

KKR Method

Applications

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3-D Photonic Crystal—Research, Optical computer

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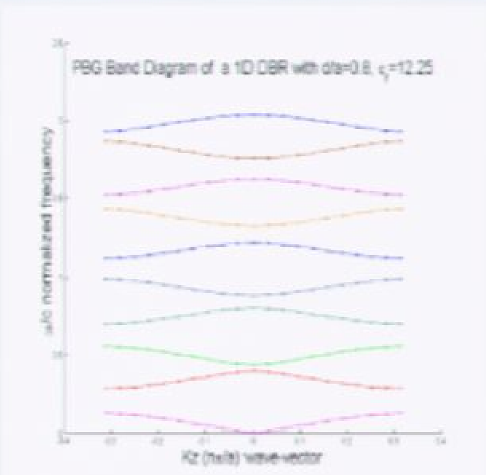

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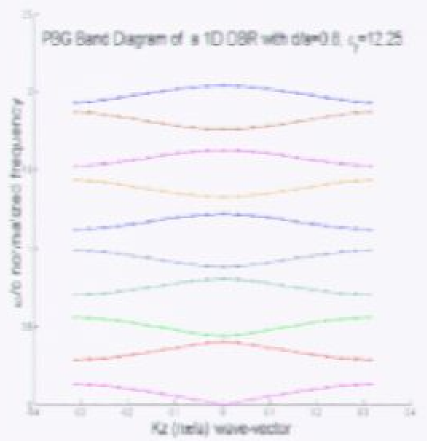

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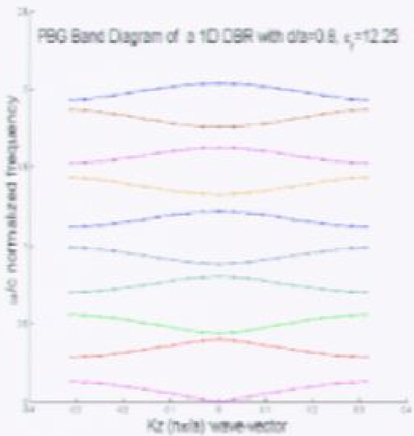

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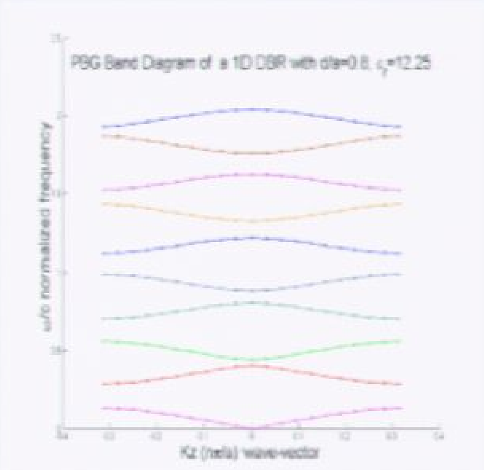

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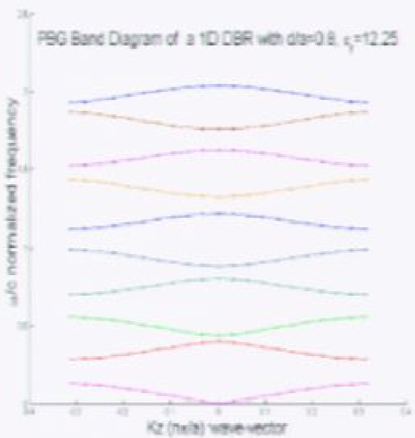

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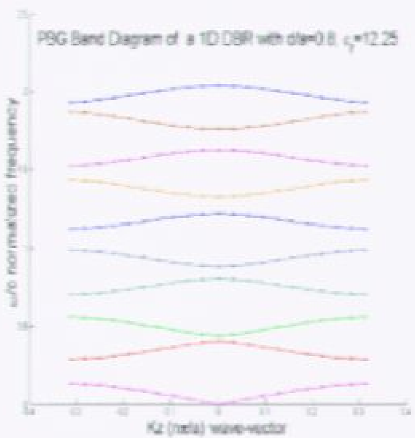

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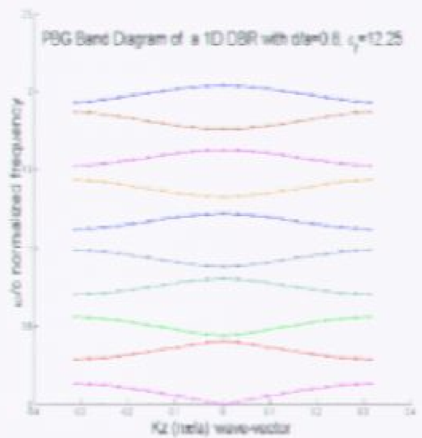

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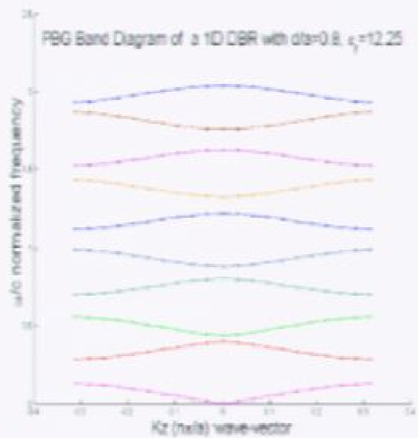

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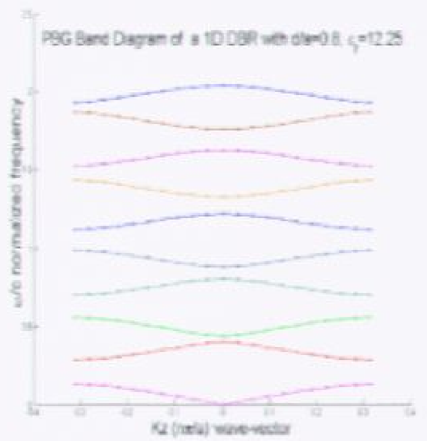

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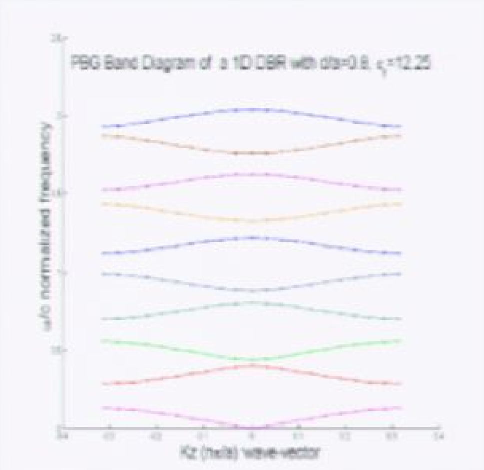

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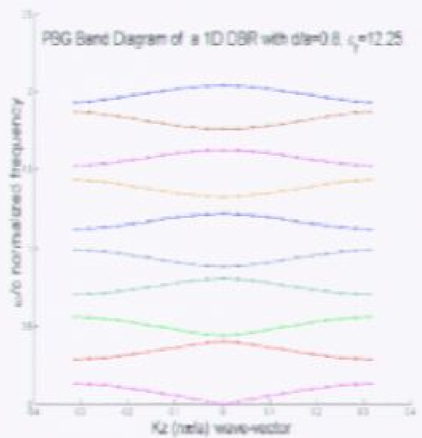

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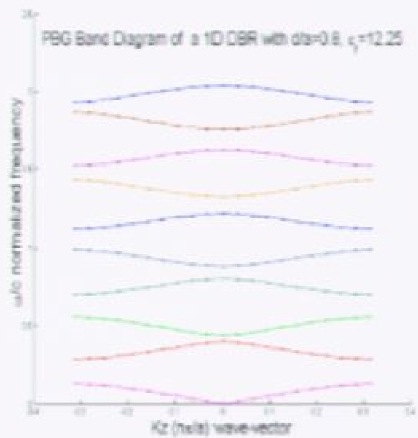

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A type of propagation of disturbance

Carries energy through a medium

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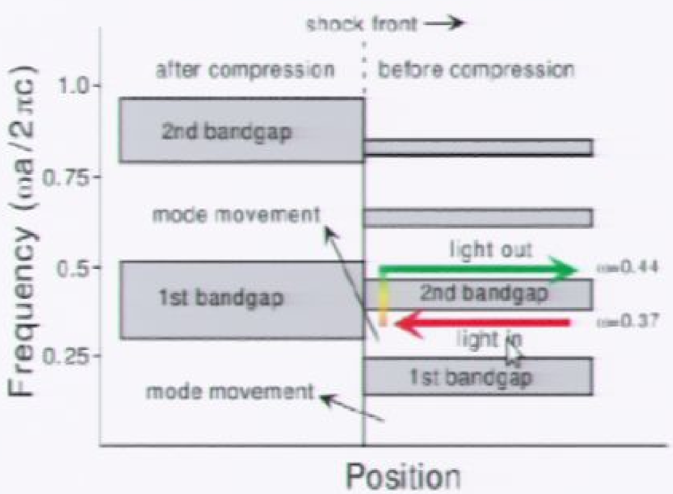

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The amount of frequency shift depends on the size of the bandgap of the pre-shocked crystal.

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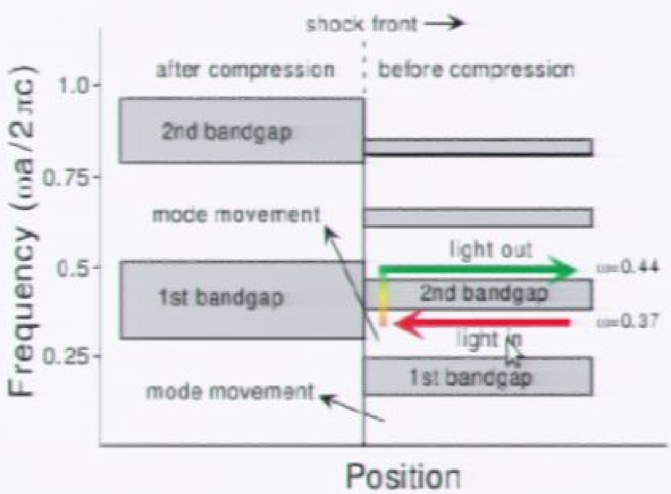

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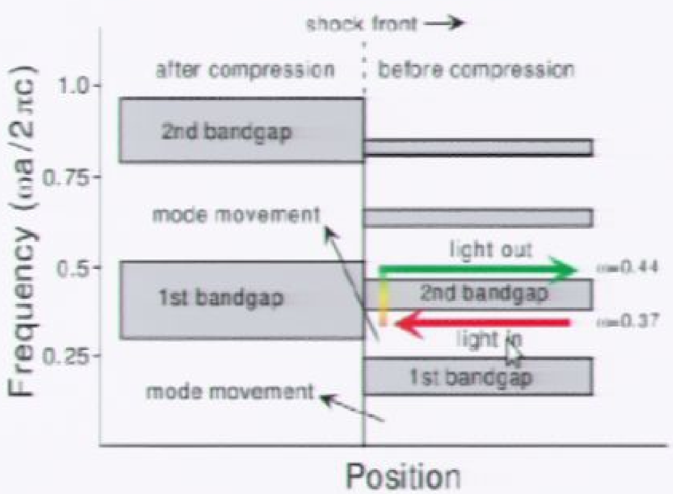

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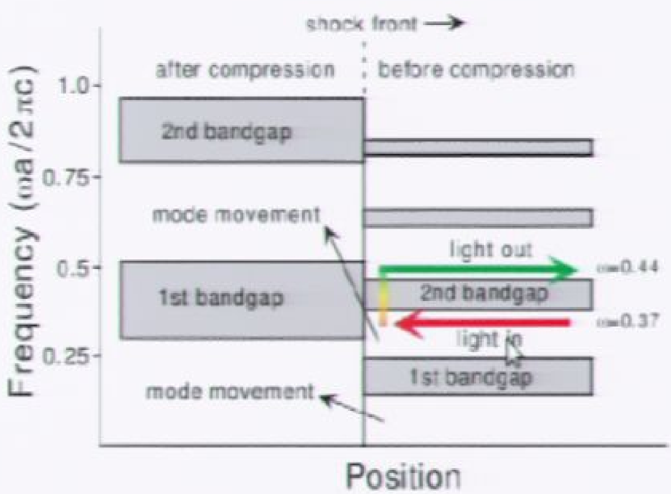

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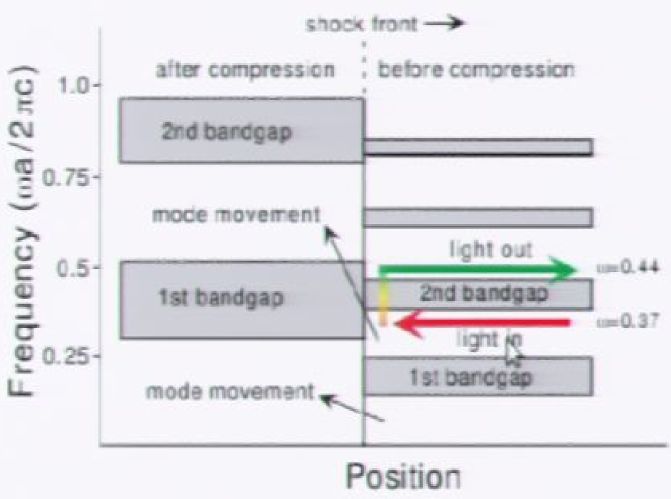

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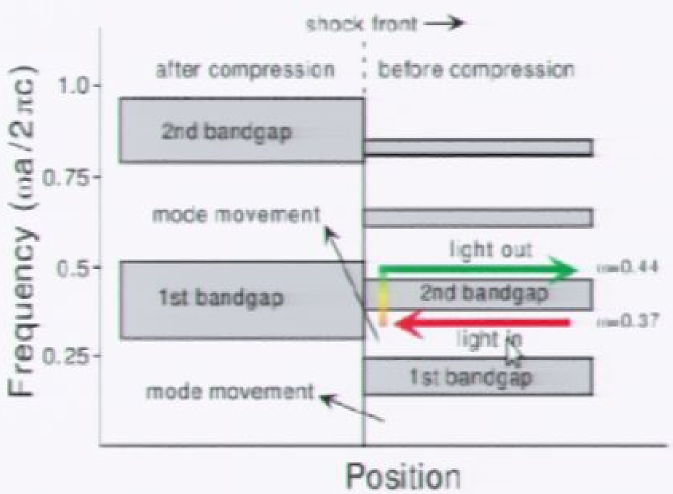

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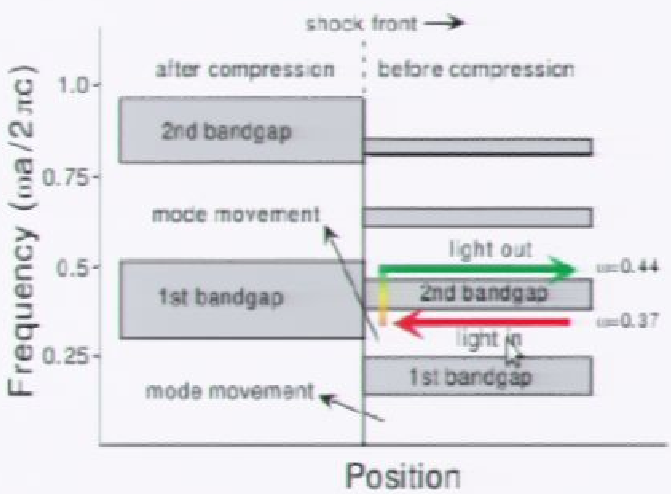

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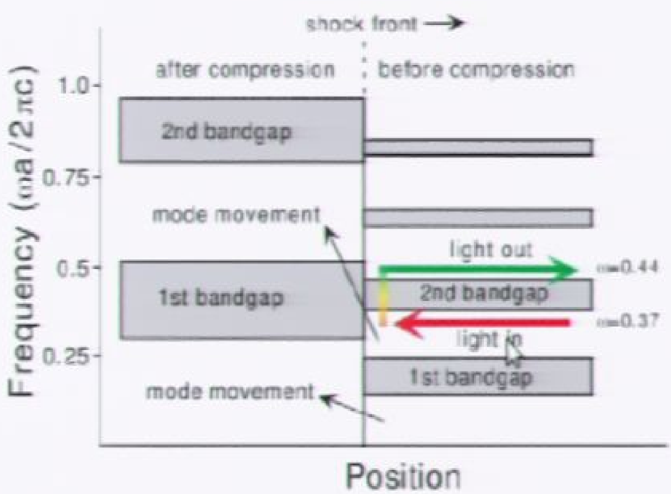

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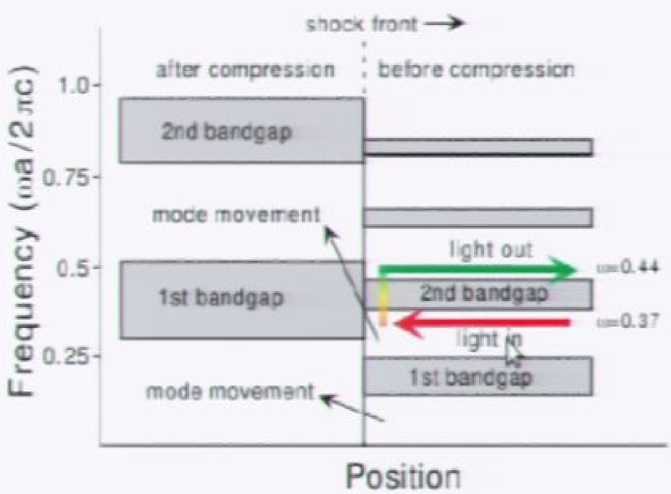

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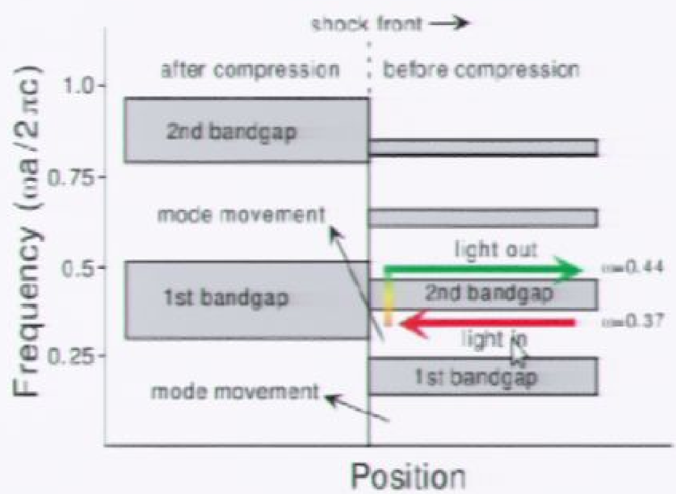

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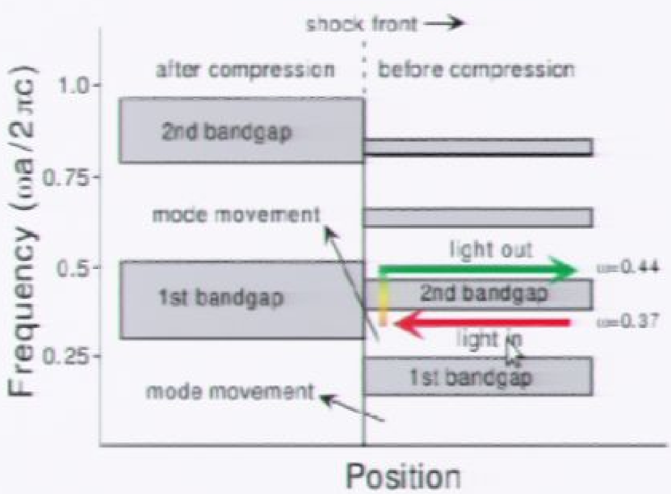

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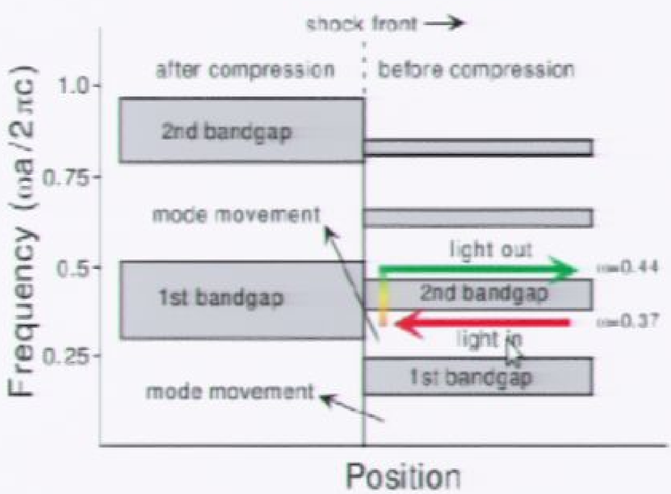

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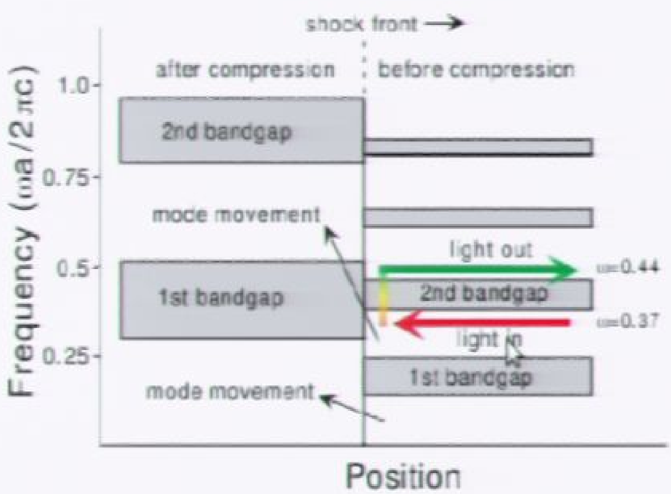

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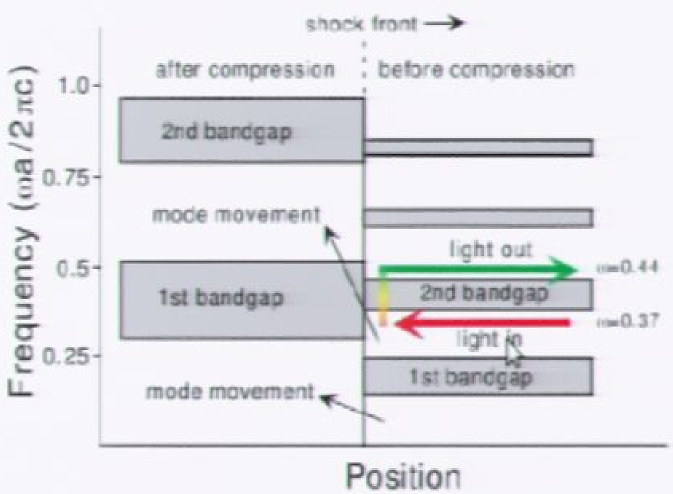


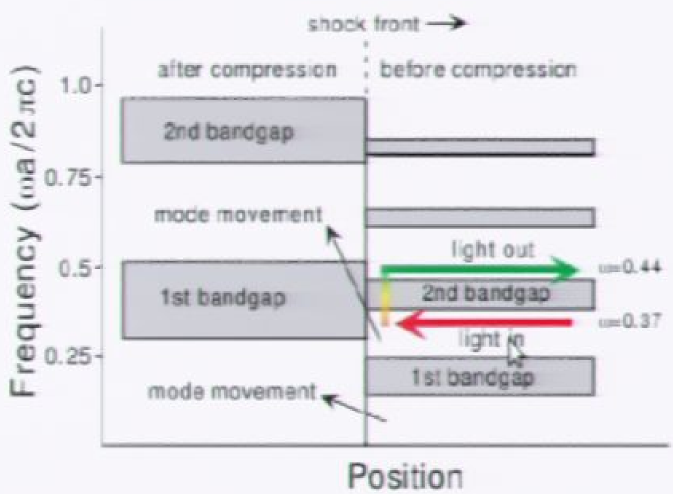
Frequncy Shift

Frequency of light is shifted to the top of the bandgap.

The amount of frequency shift depends on the size of the bandgap of the pre-shocked crystal.

Shock Wave in a Photonic Crystal

Frequency – Position



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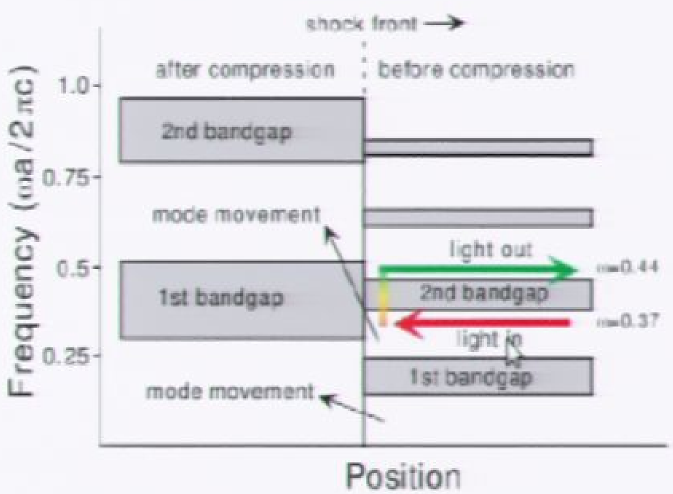

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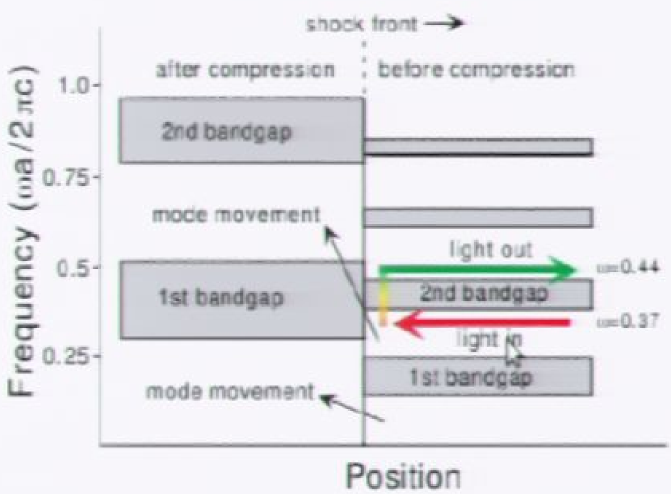

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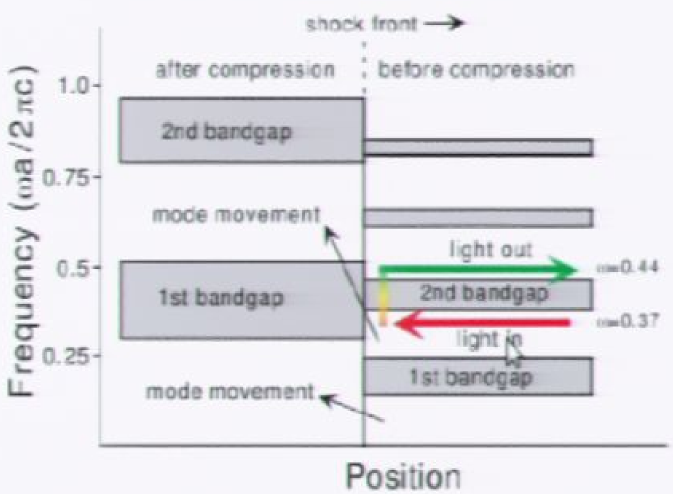

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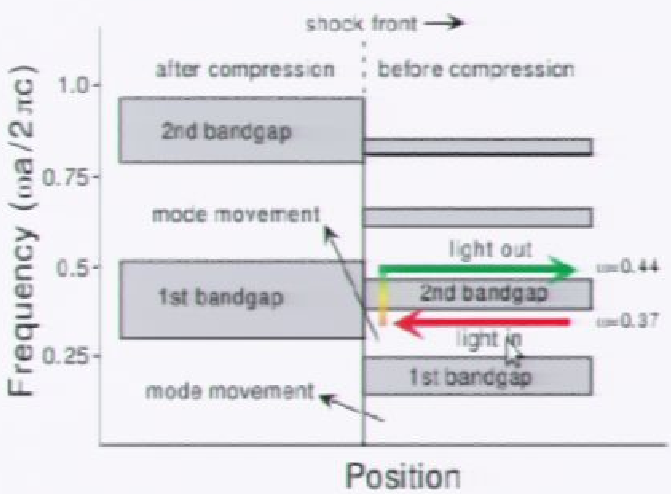

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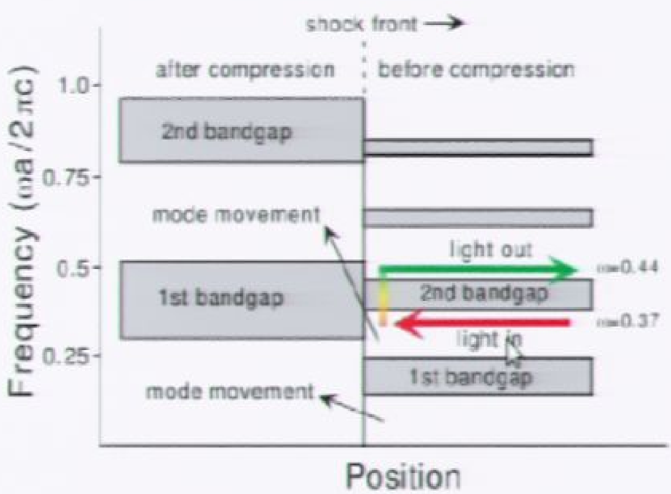

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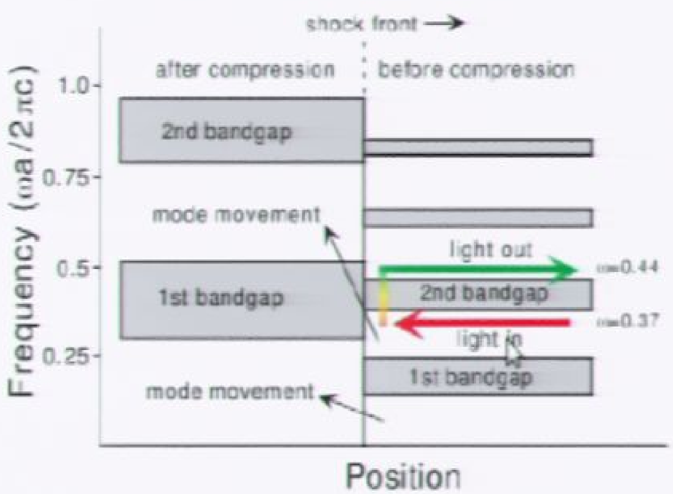

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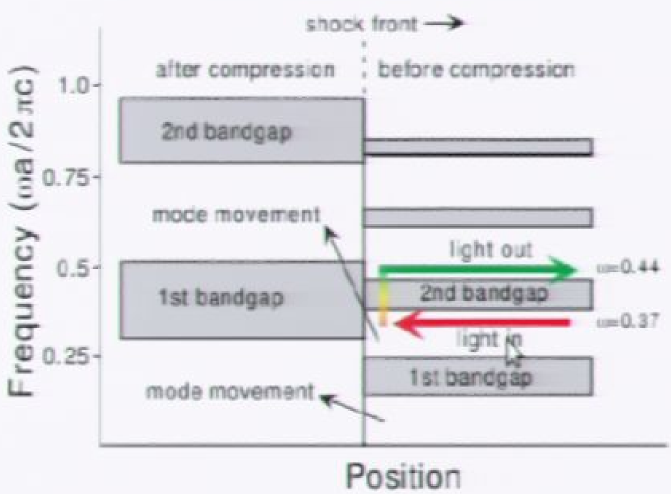

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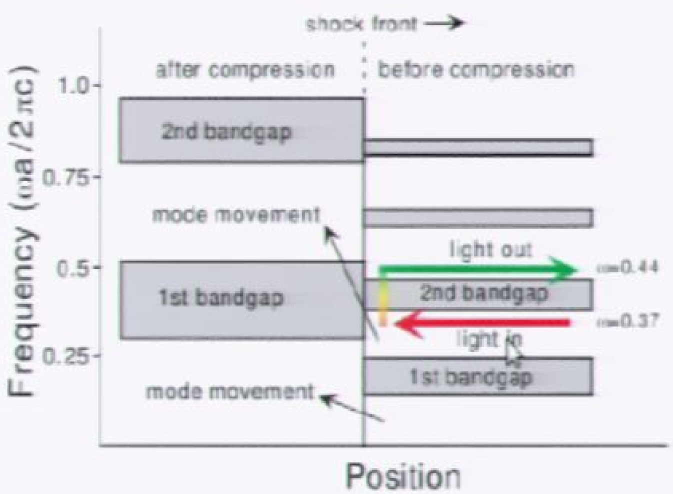

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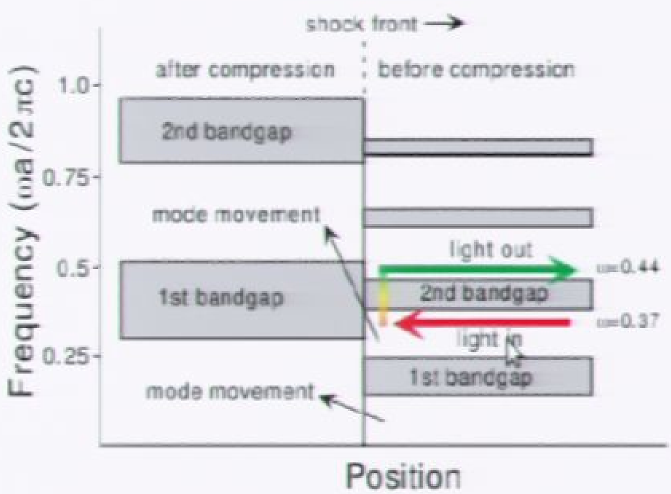

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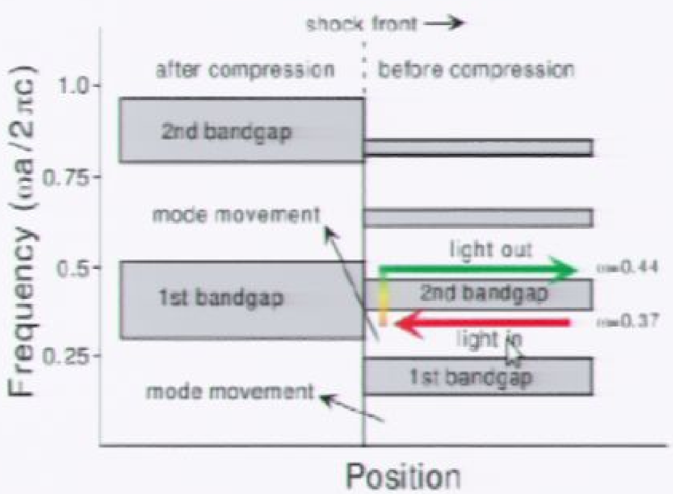

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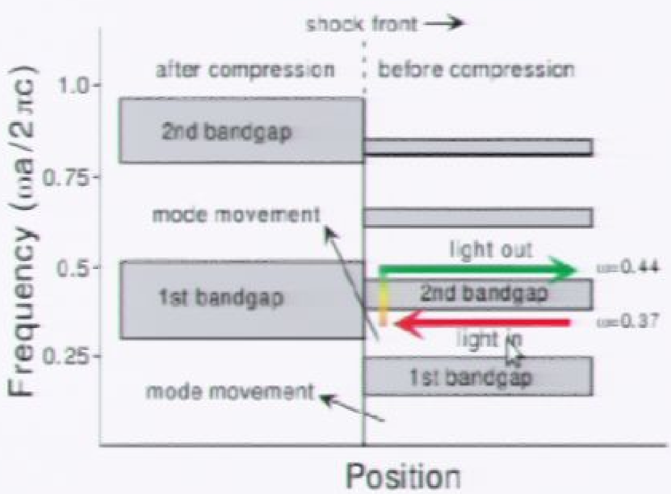

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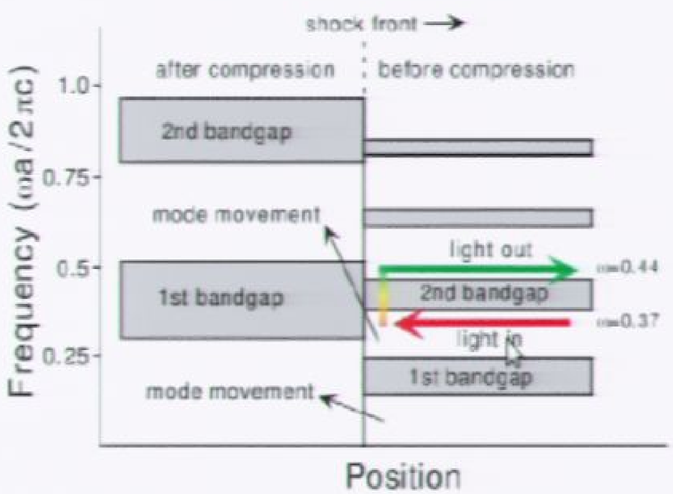

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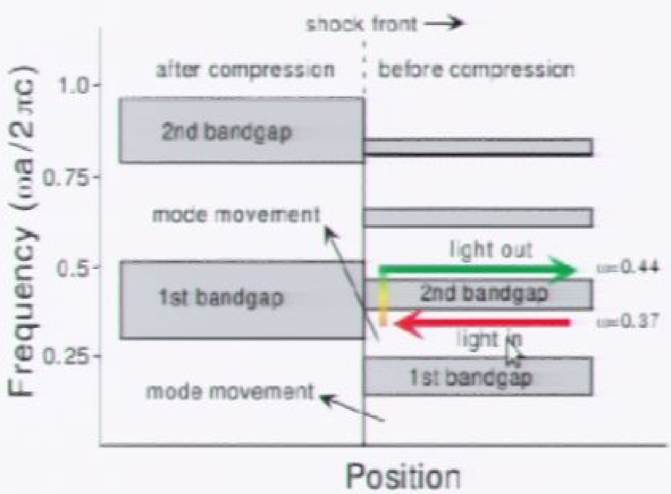

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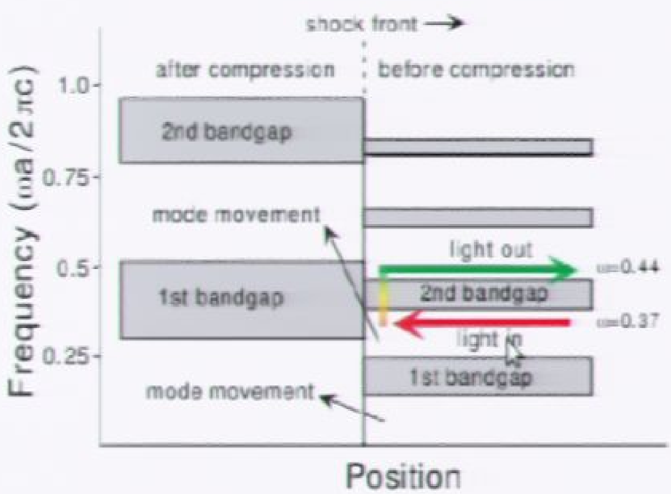

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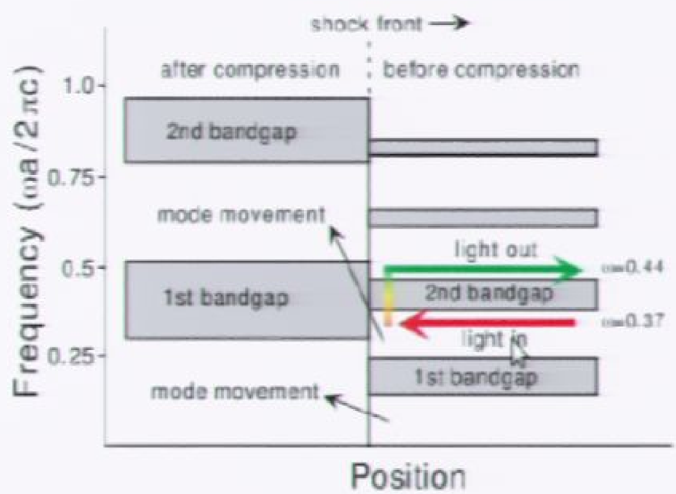

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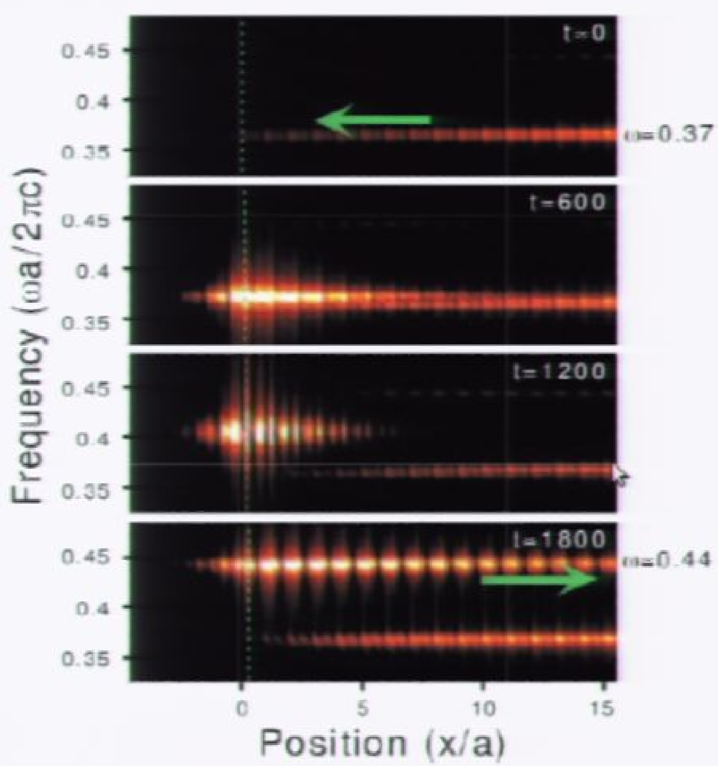

Localization of Light

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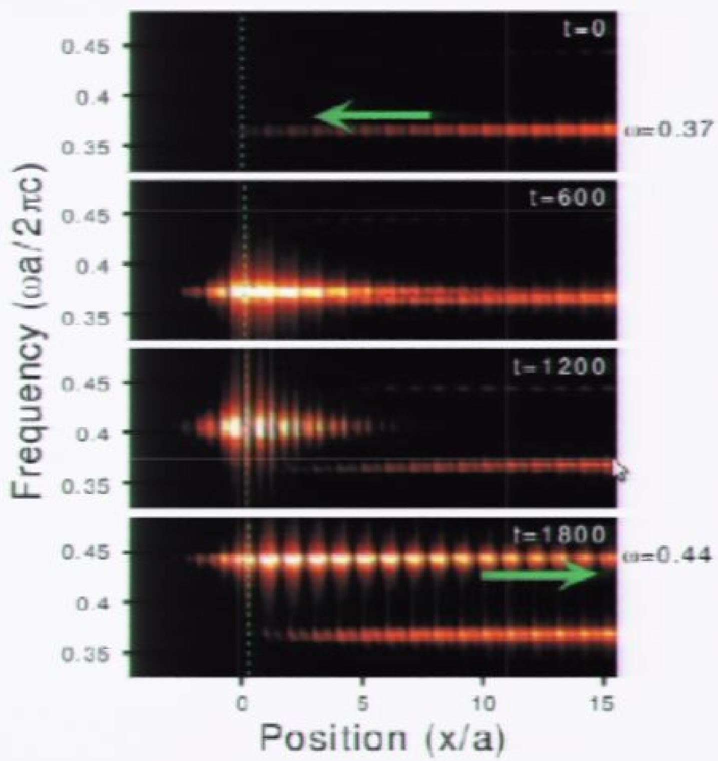
Shock Wave in a Photonic Crystal

Frequency – Position



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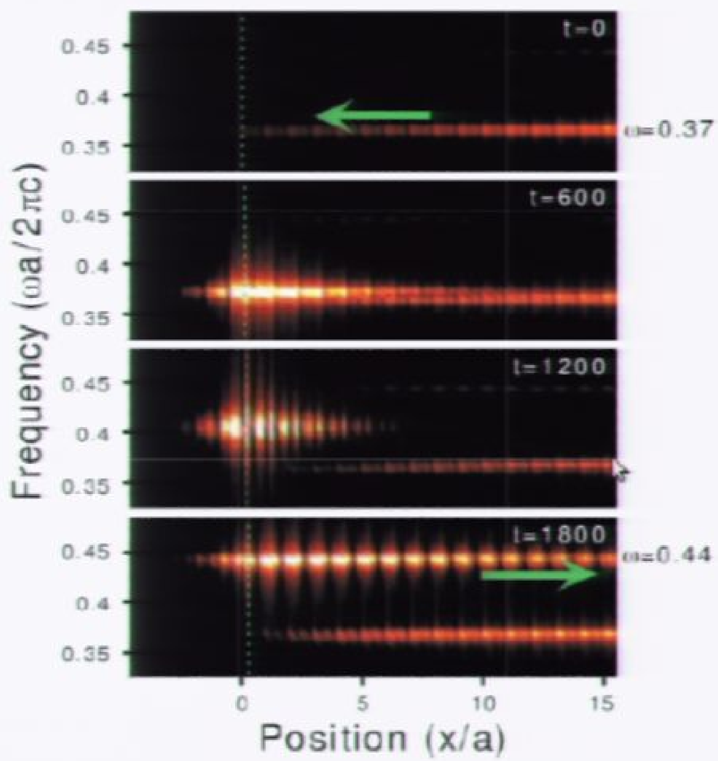

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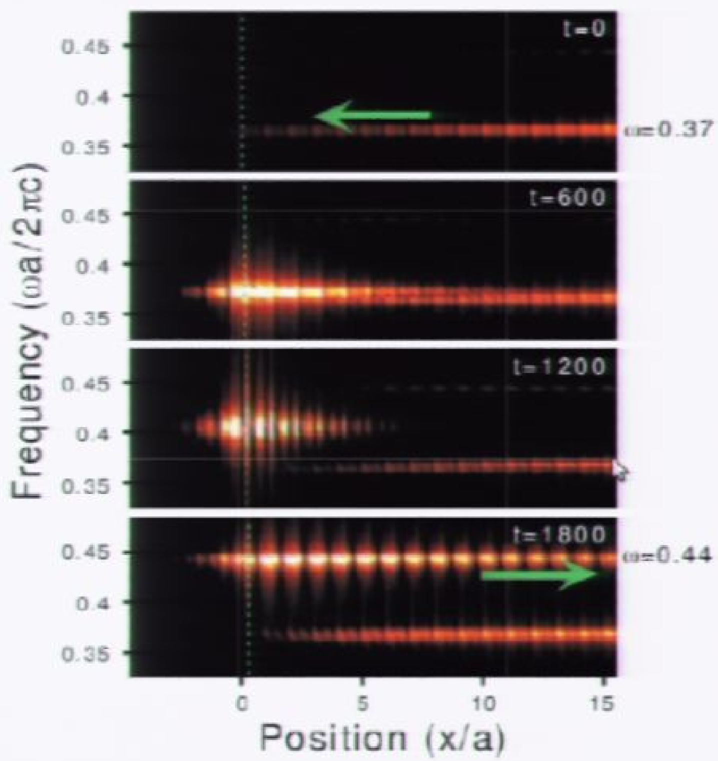

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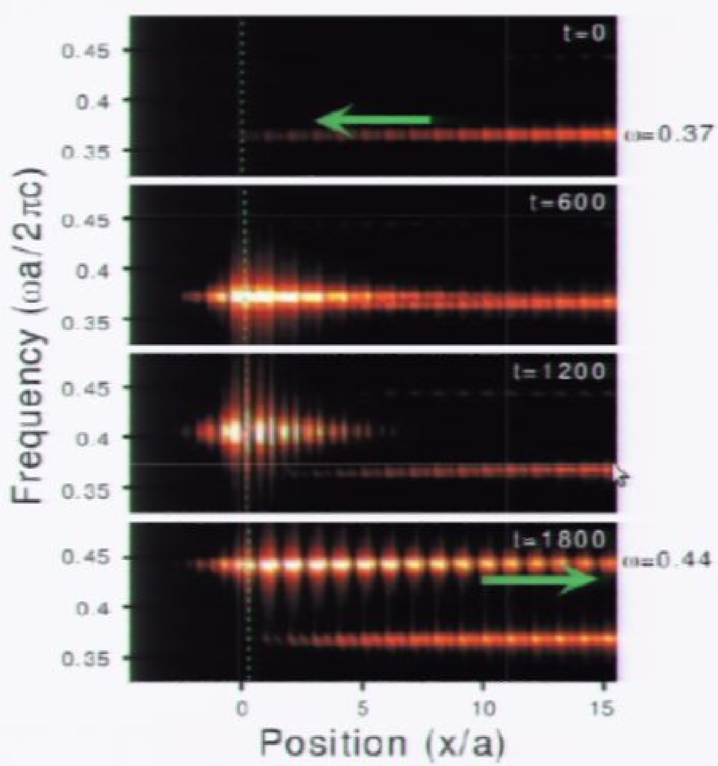

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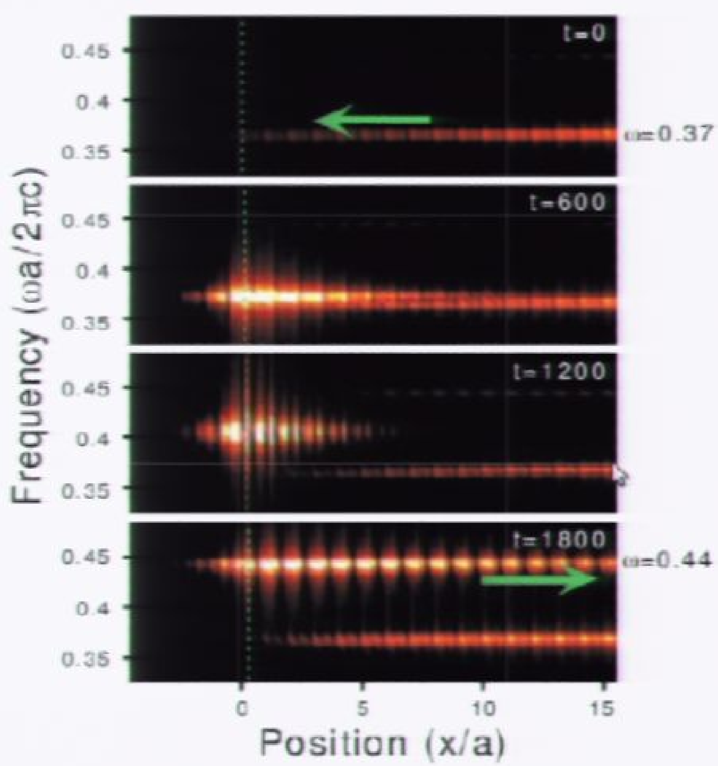

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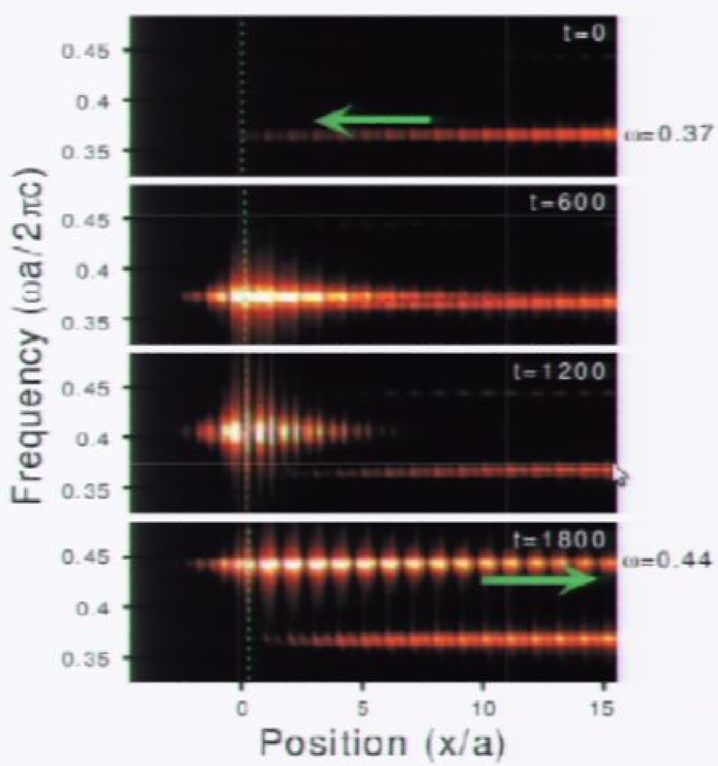

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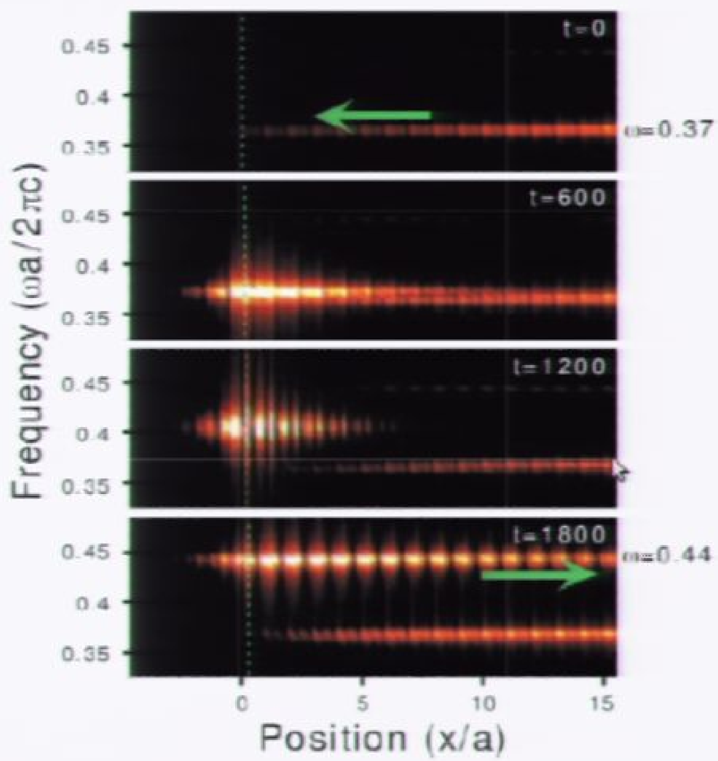

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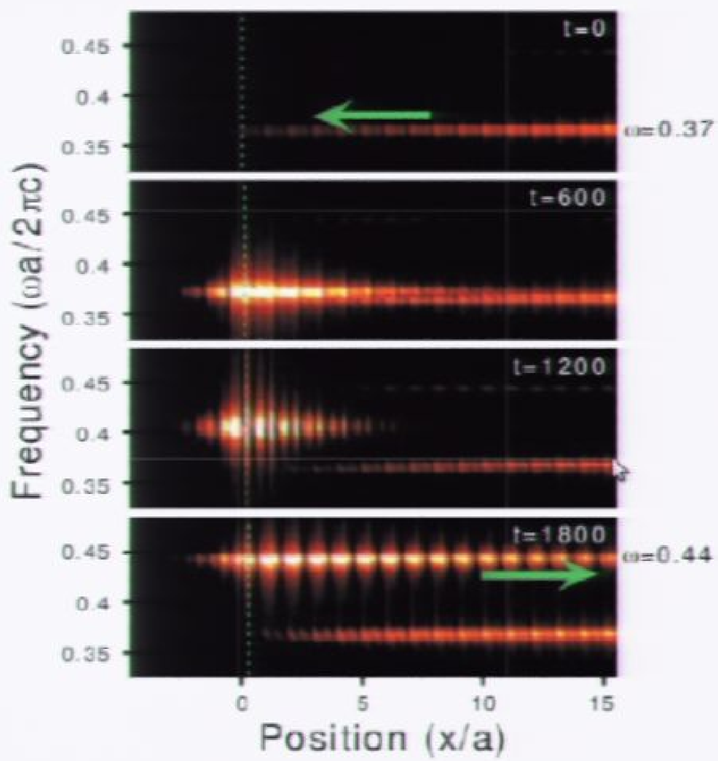

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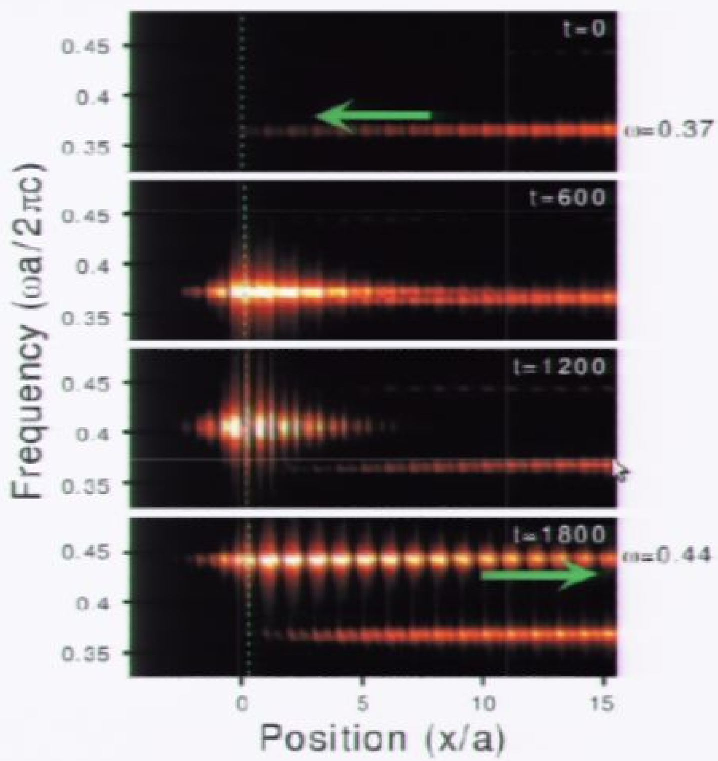

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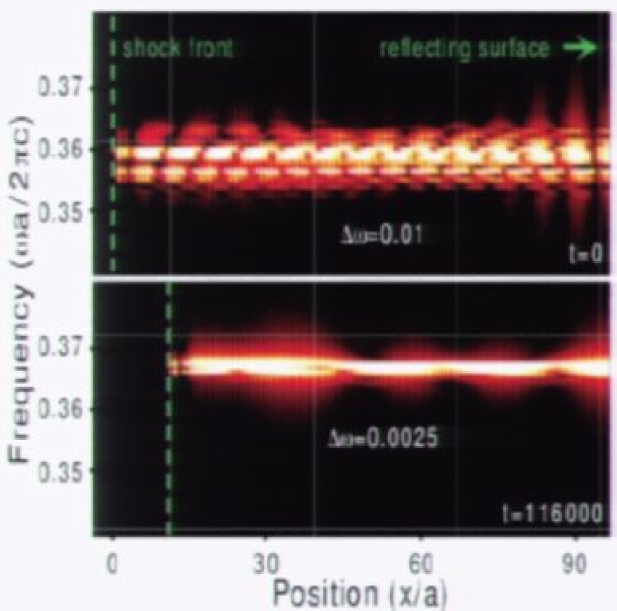


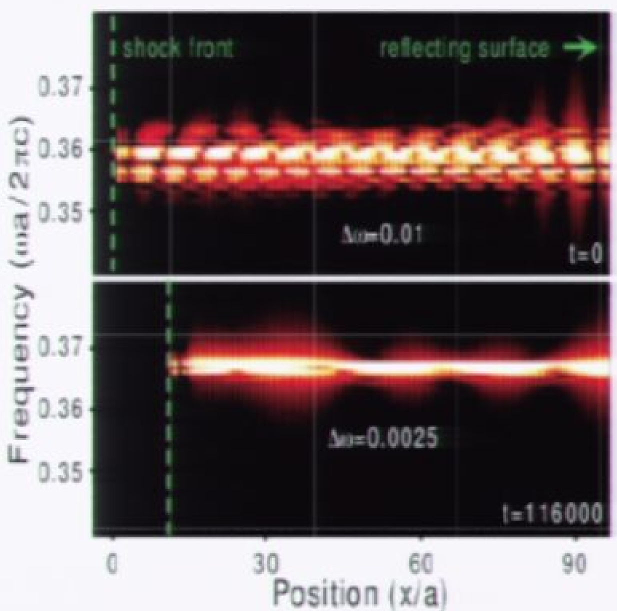
Bandwidth Narrowing

The slower of the shock velocities are, the more the bandwidth is narrowed.

Unlike bandwidth broading, bandwidth narrowing have not been obtained in non-linear systems.

Shock Wave in a Photonic Crystal

Frequency – Position



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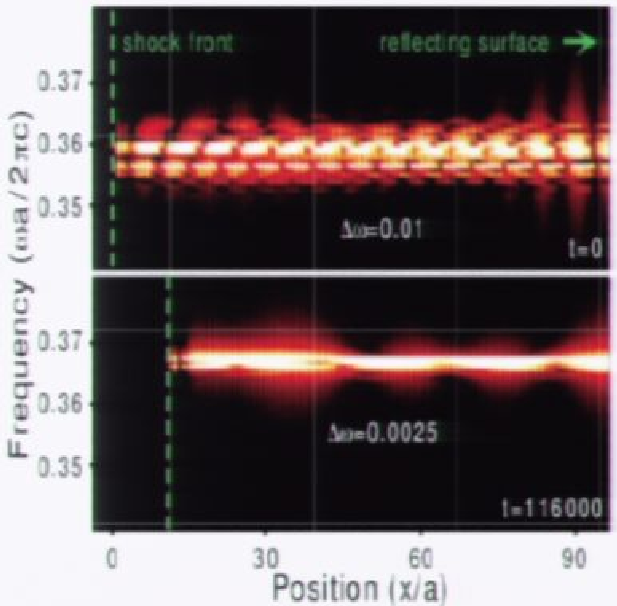

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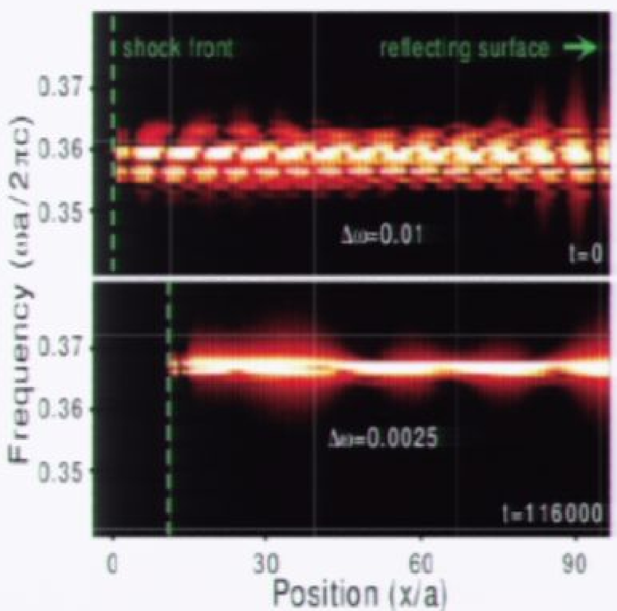

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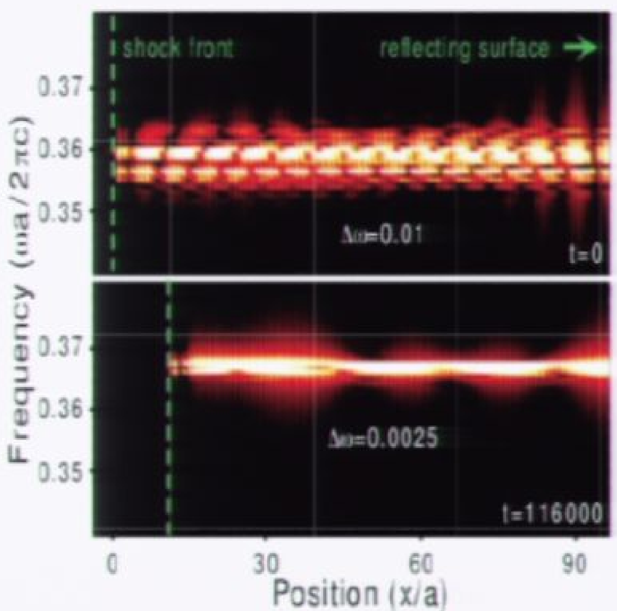

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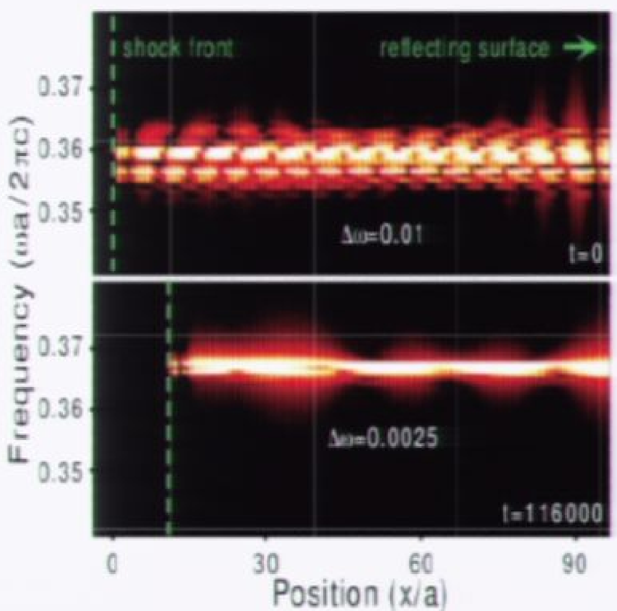

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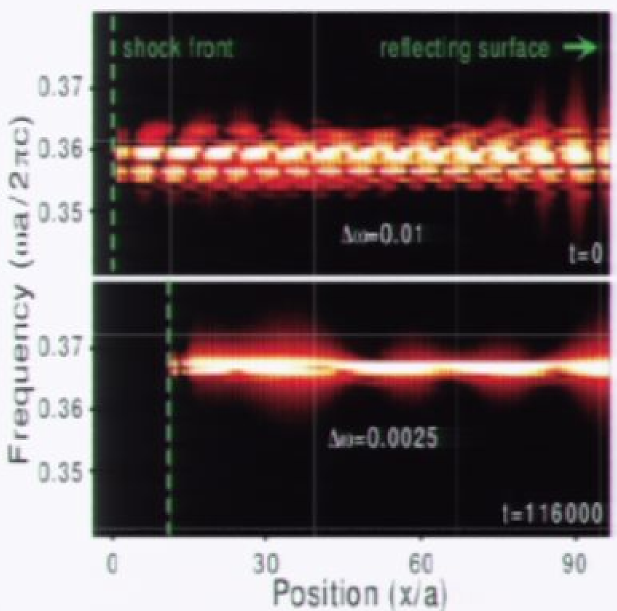

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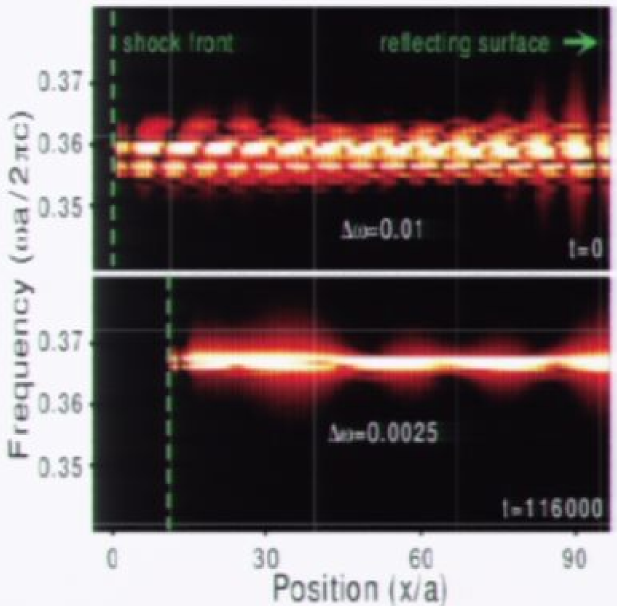

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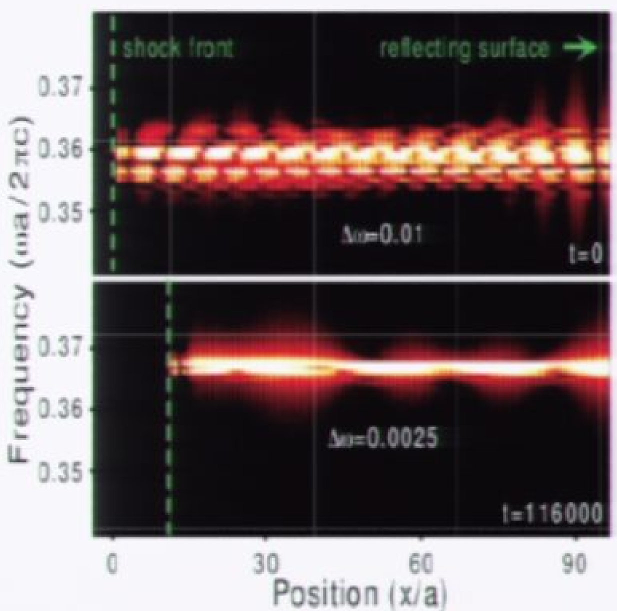

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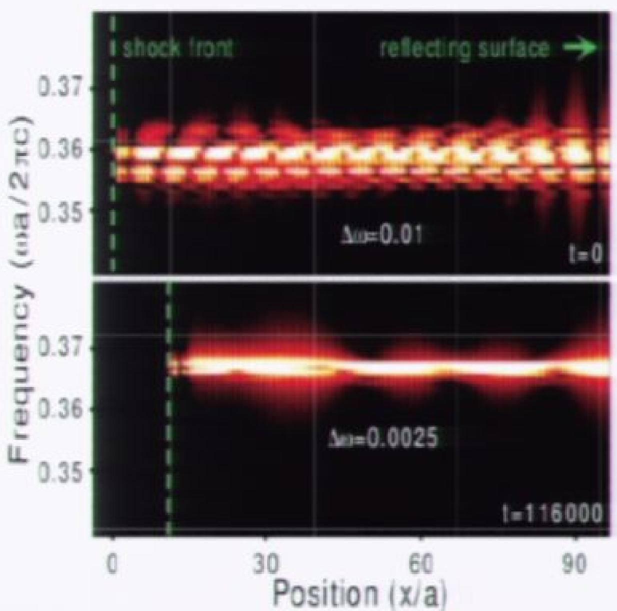

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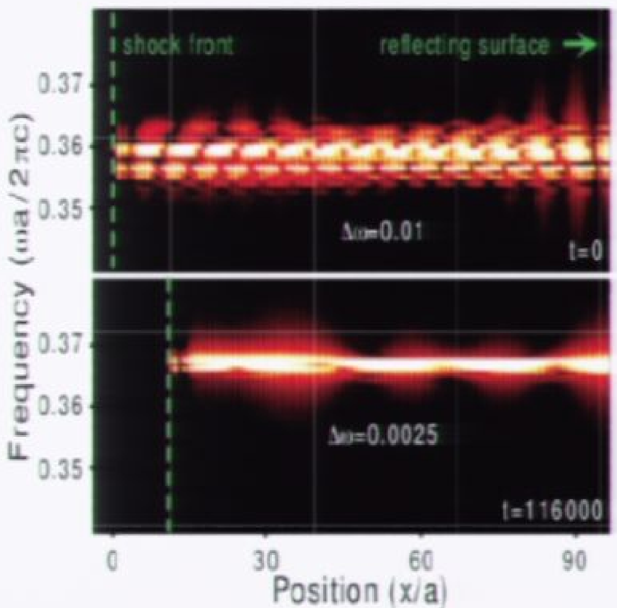

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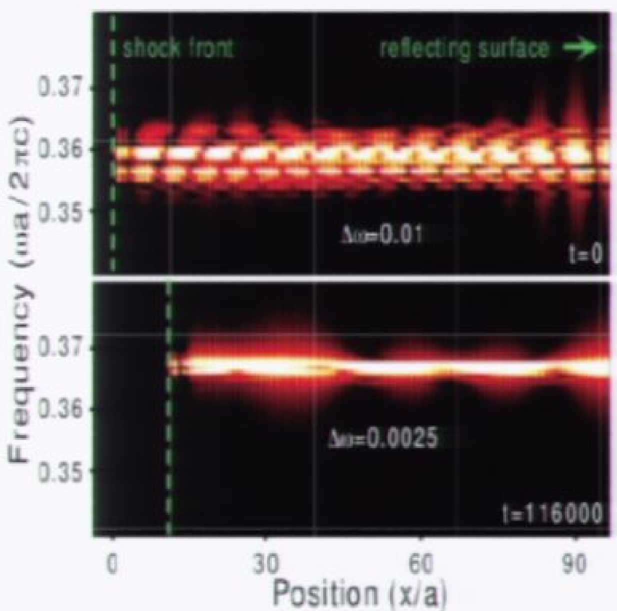

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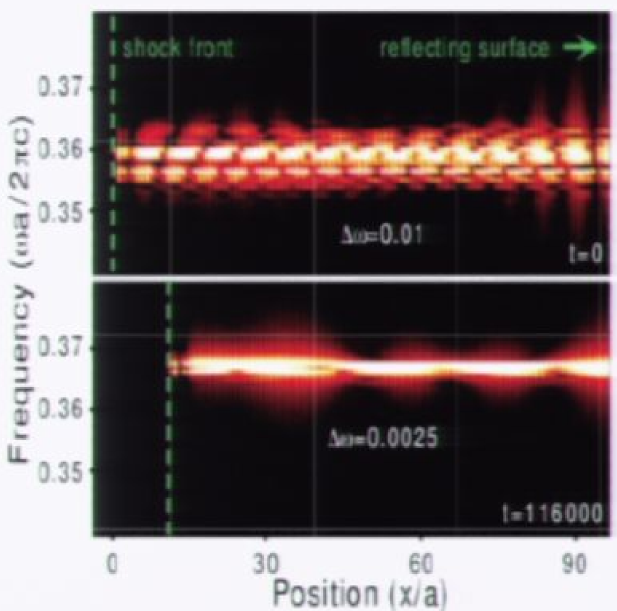

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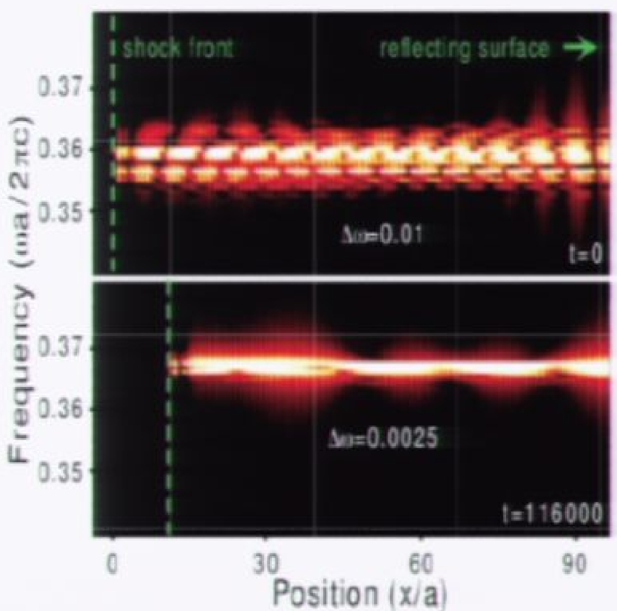

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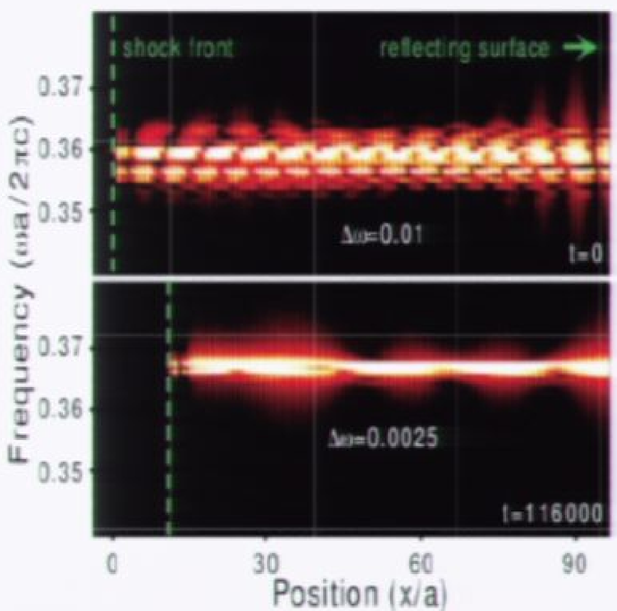

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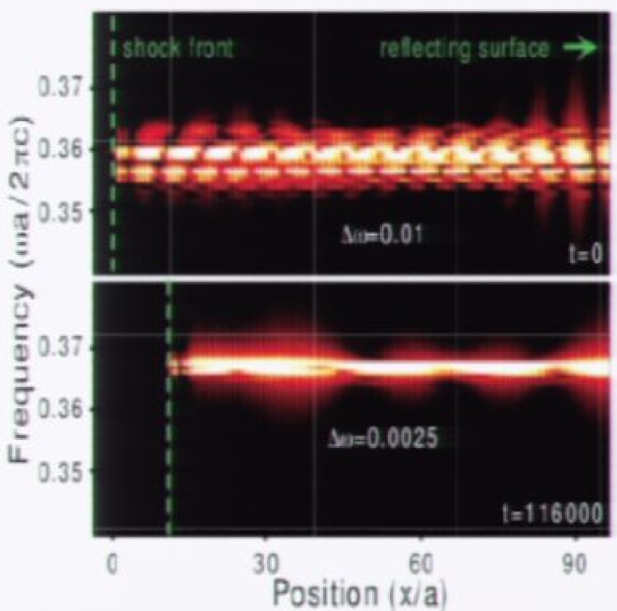

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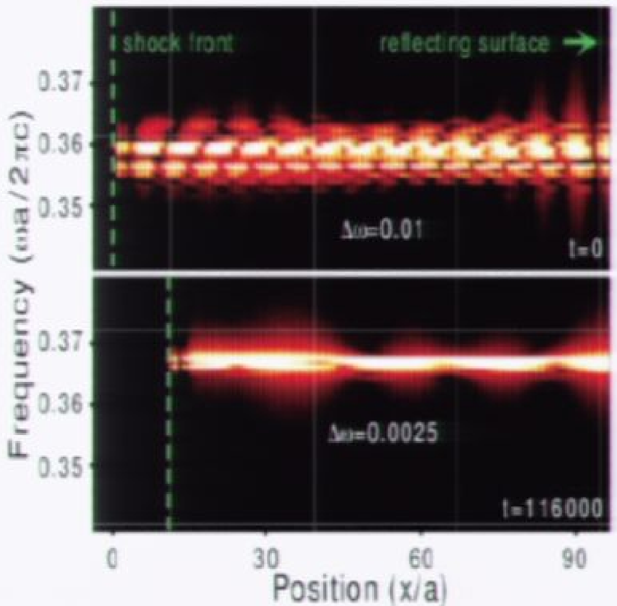

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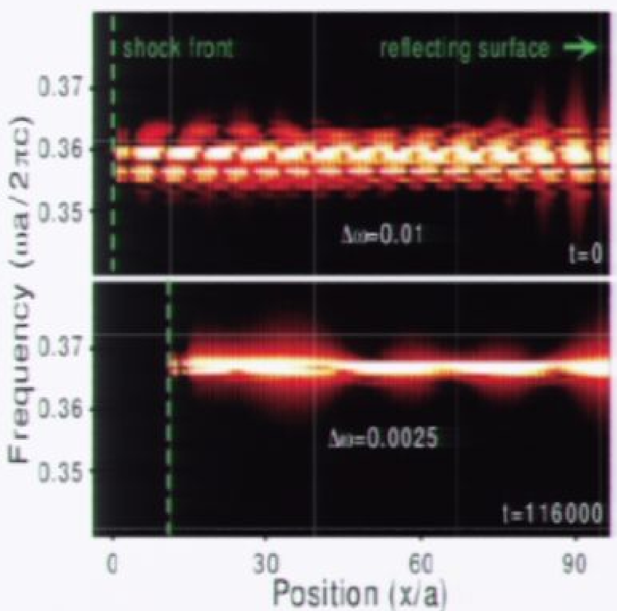

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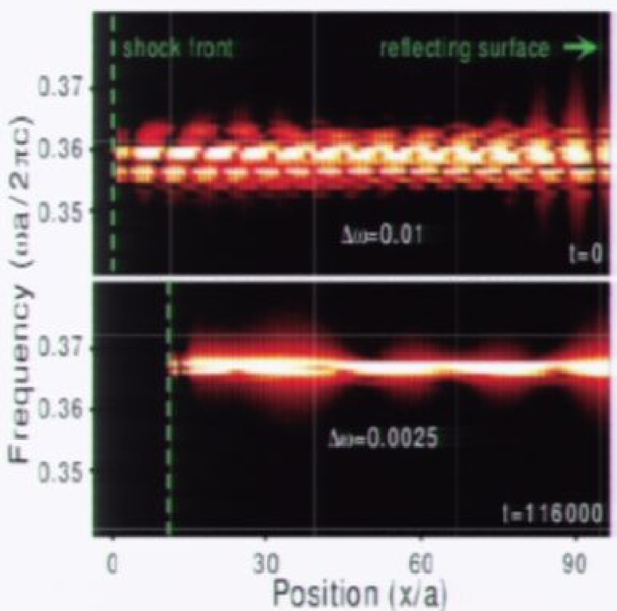

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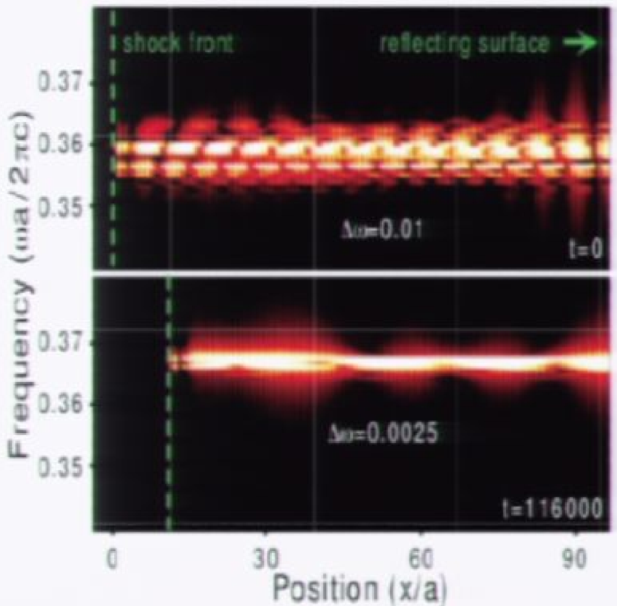

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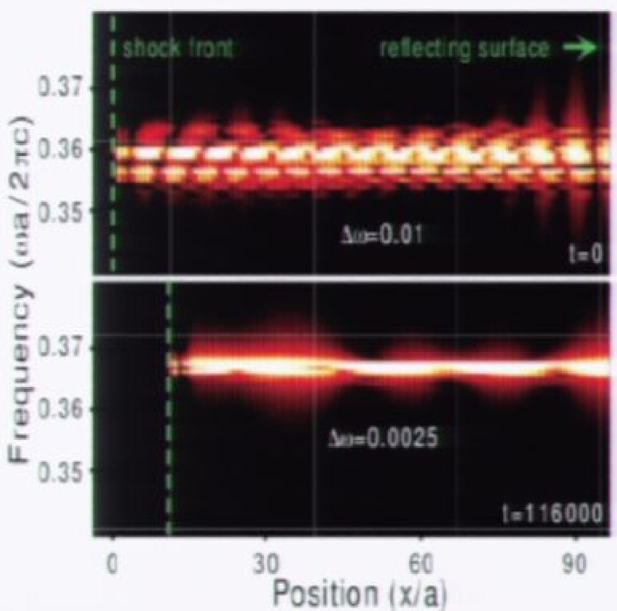

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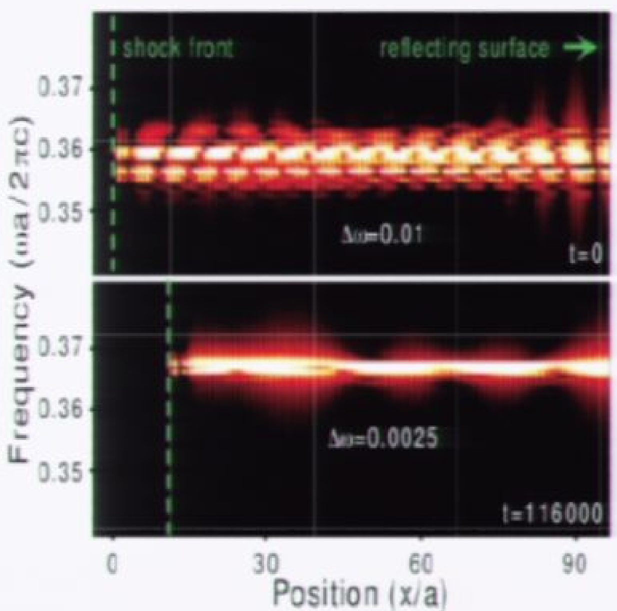

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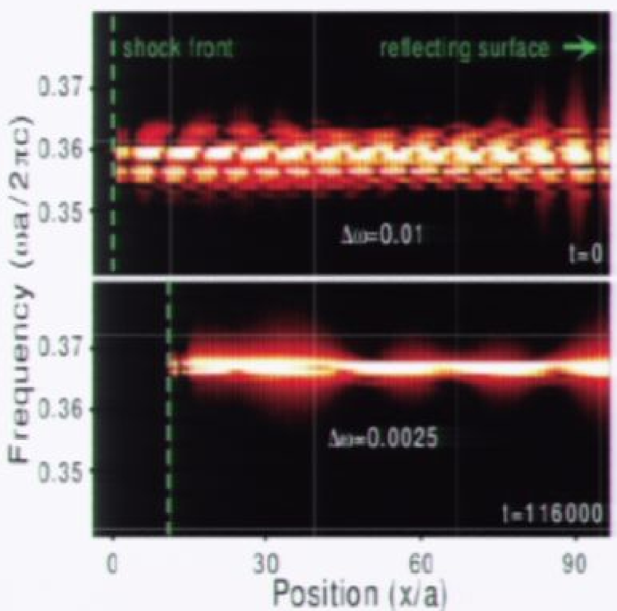

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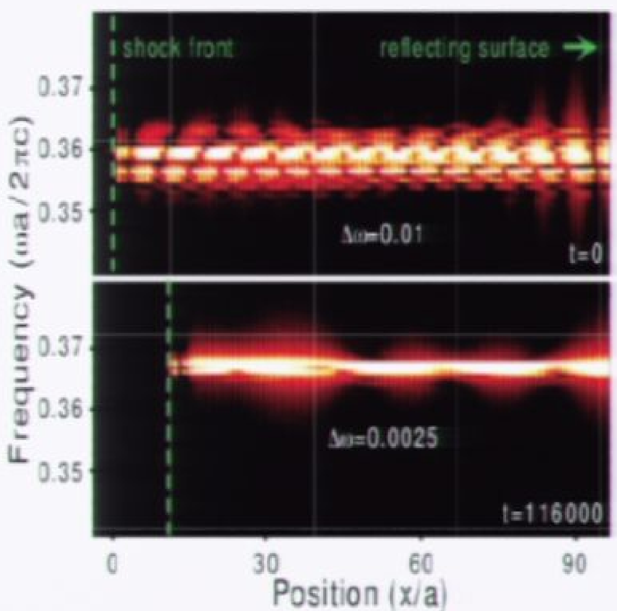

Bandwidth Narrowing

The slower of the shock velocities are, the more the bandwidth is narrowed.

Unlike bandwidth broading, bandwidth narrowing have not been obtained in non-linear systems.

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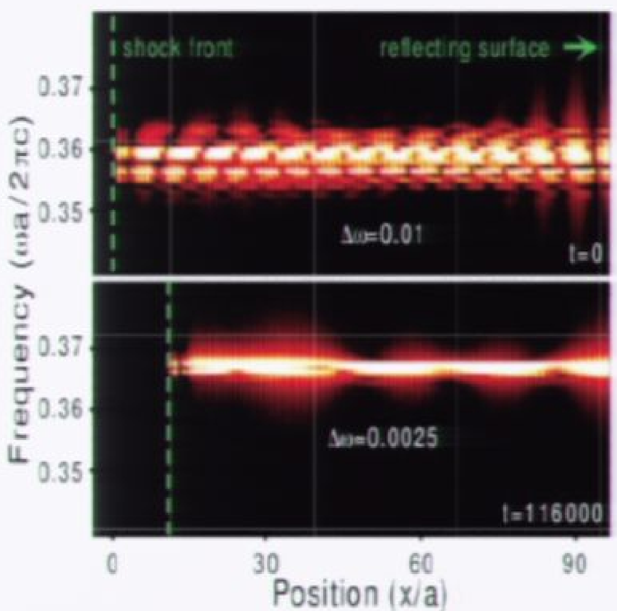

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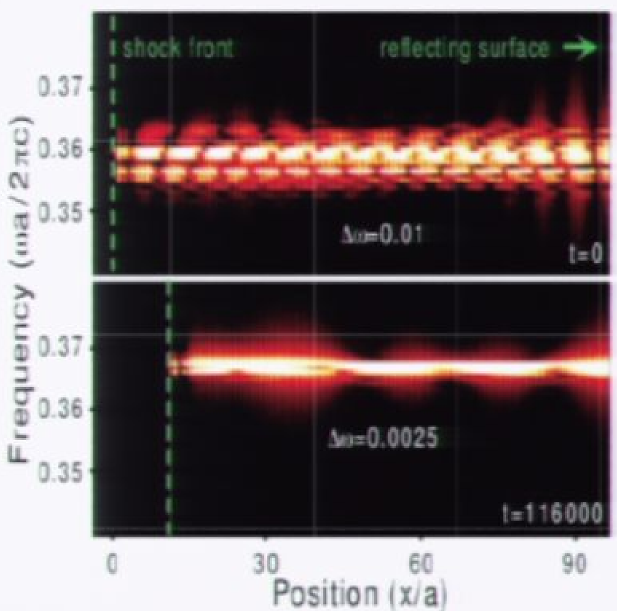

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Possible Properties

No photon absorbed or re-emitted

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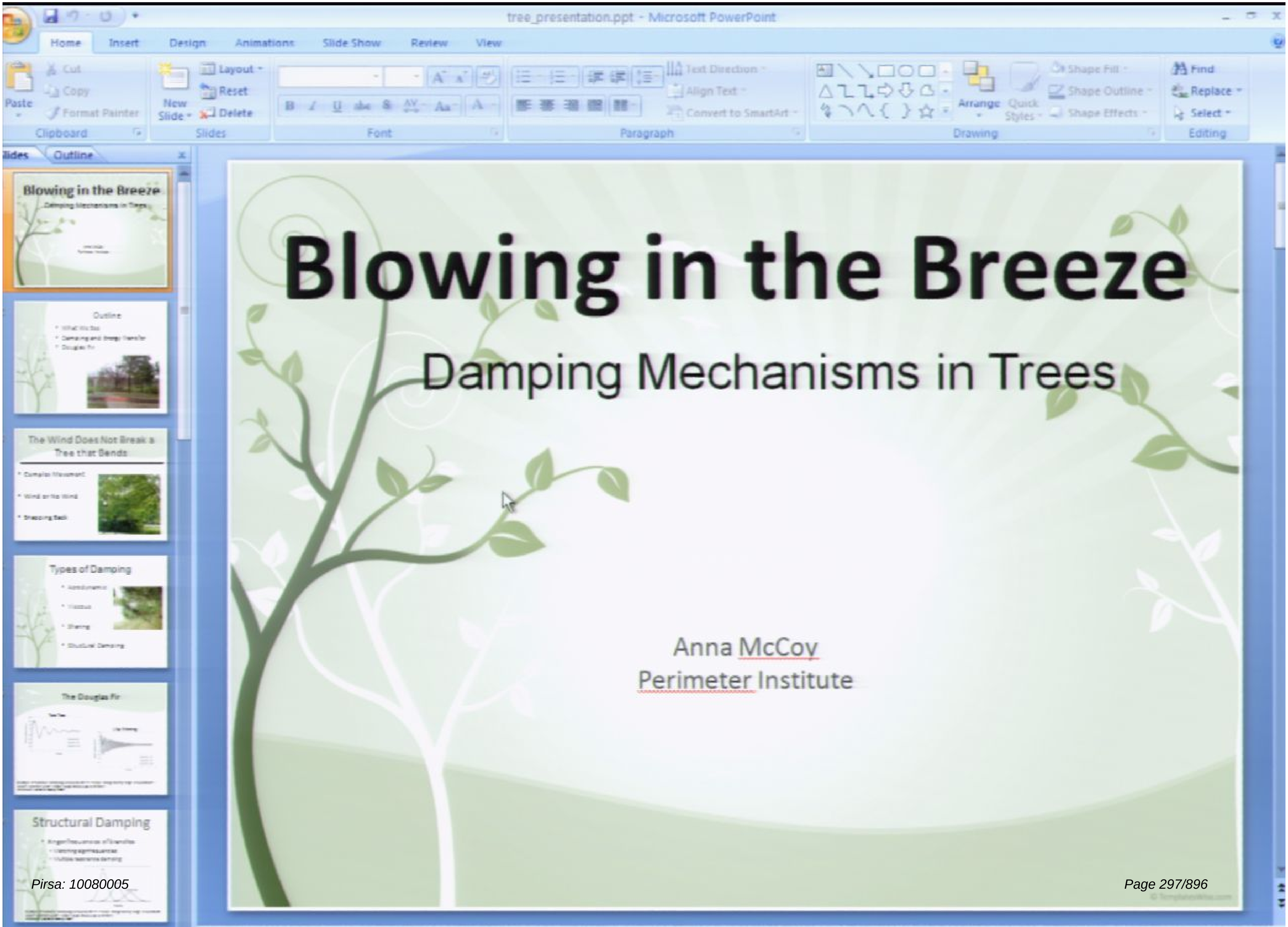
Reference

[1]http://en.wikipedia.org/wiki/Photonic_crystal
[2]http://en.wikipedia.org/wiki/Opal
[3]Solid State Communications, Vol.102, No.2-3, pp.165-173, 1997
[4]The color of shock waves in photonic crystals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Blowing in the Breeze
Damping Mechanisms in Trees
Anna McCoy
Perimeter Institute
Outline
The Wind Does Not Break a Tree that Bends
Types of Damping
The Douglas Fir
Structural Damping

Outline

- What We See
- Damping and Energy Transfer
- Douglas Fir

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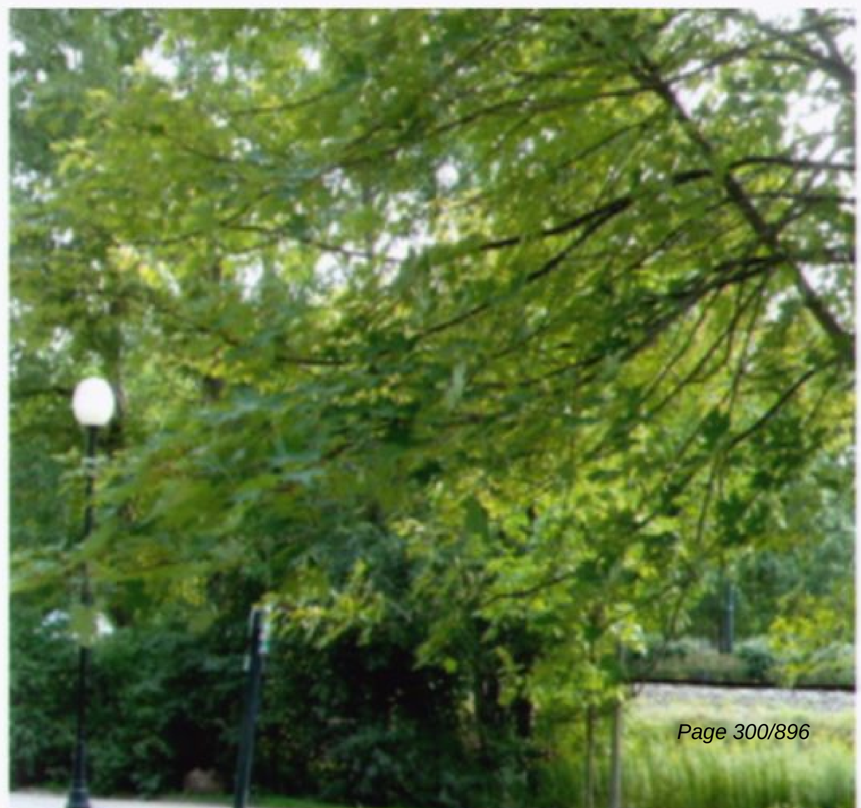
The Wind Does Not Break a Tree that Bends

- Complex Movement
- Wind or No Wind
- Snapping Back

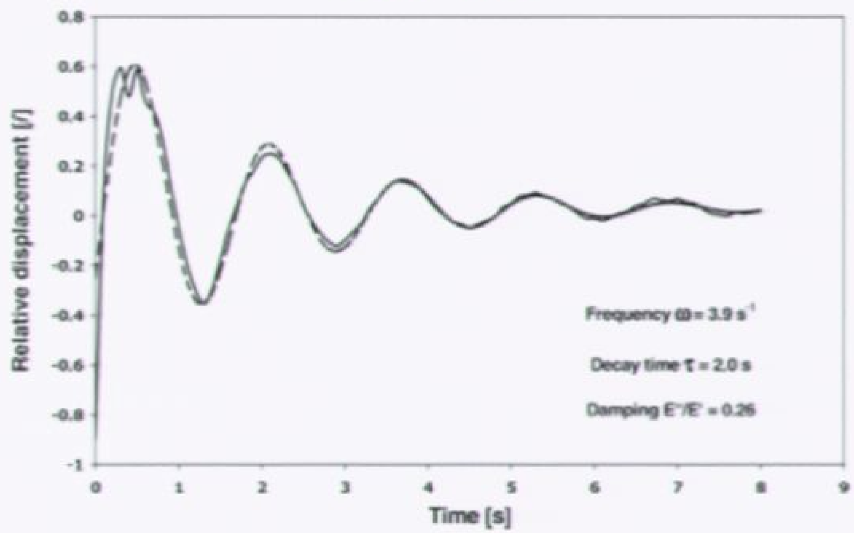


Types of Damping

- Aerodynamic
- Viscous
- Sharing
- Structural Damping

The Douglas Fir

Total Tree



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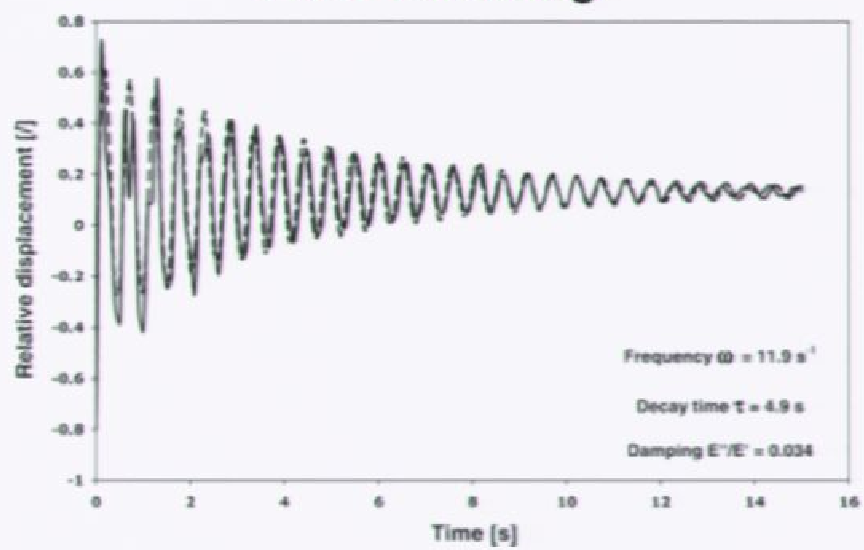

Multiple resonance damping or how do trees escape dangerously large oscillations?

Hanns-Christof Spatz, Franka Brüchert and Jochen Pfisterer

The Douglas Fir

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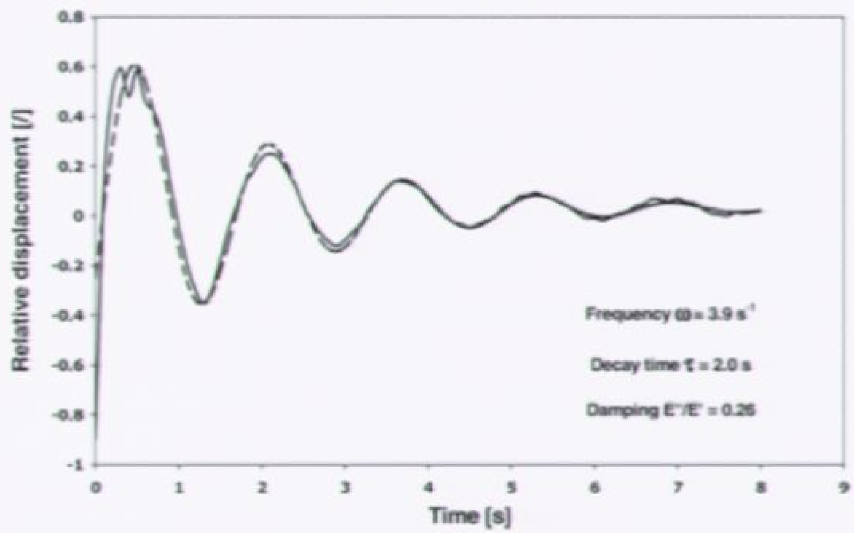

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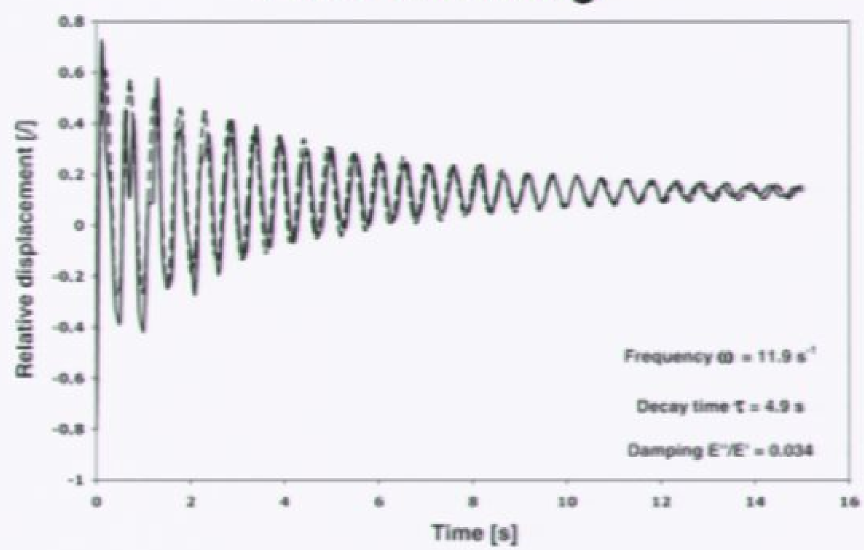

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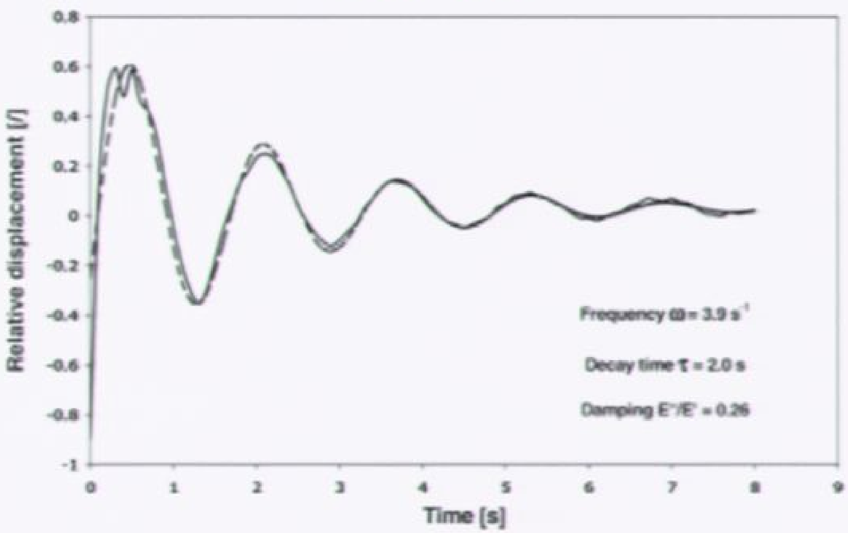

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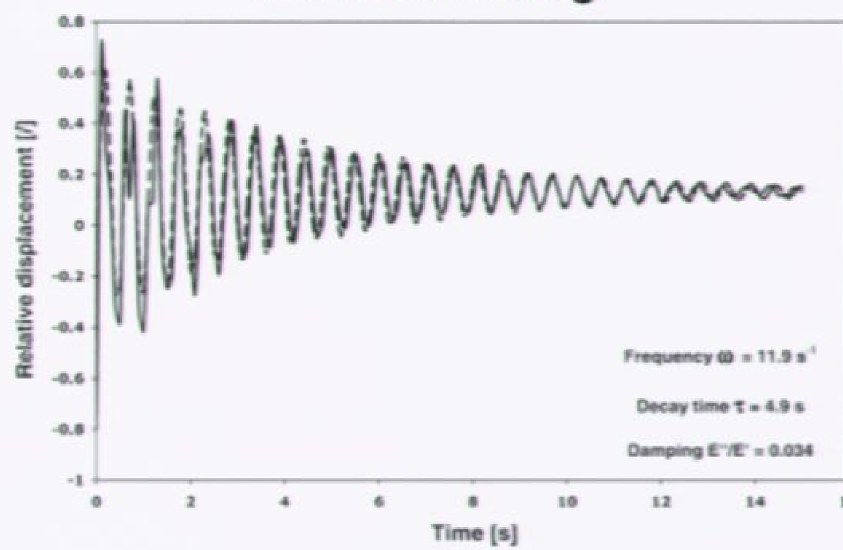

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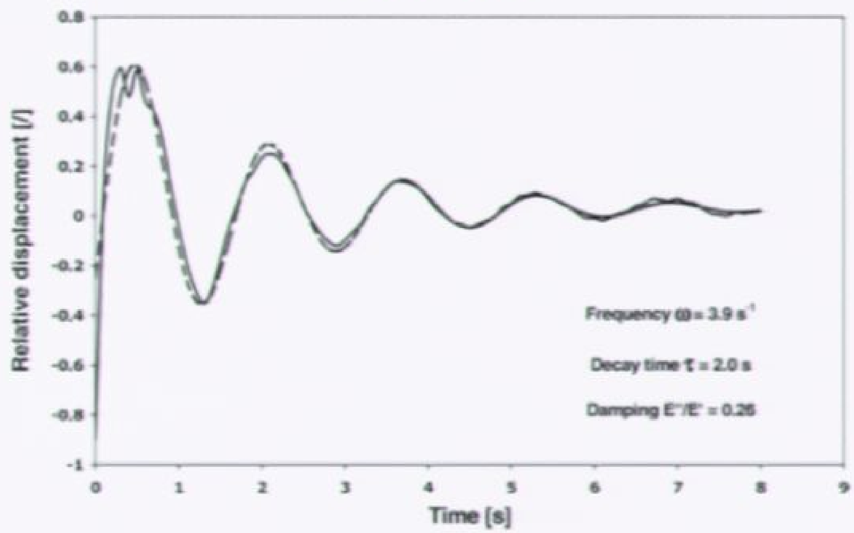

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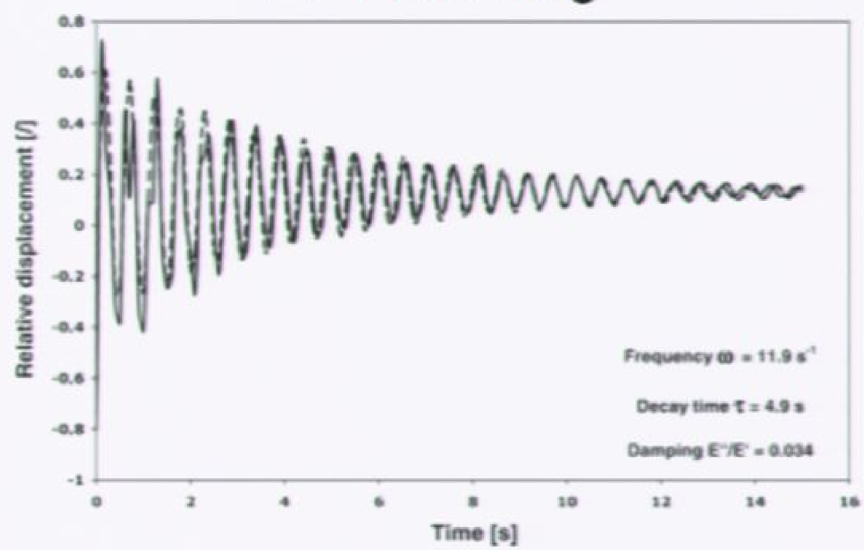

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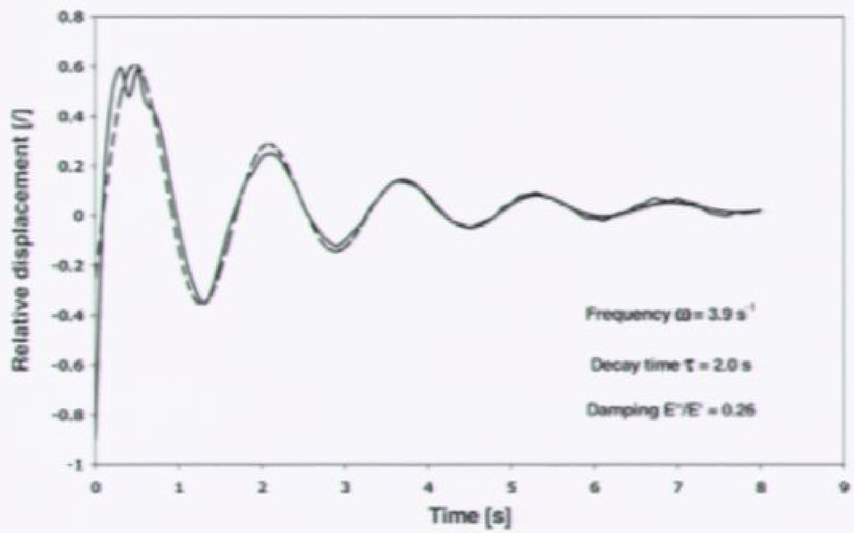

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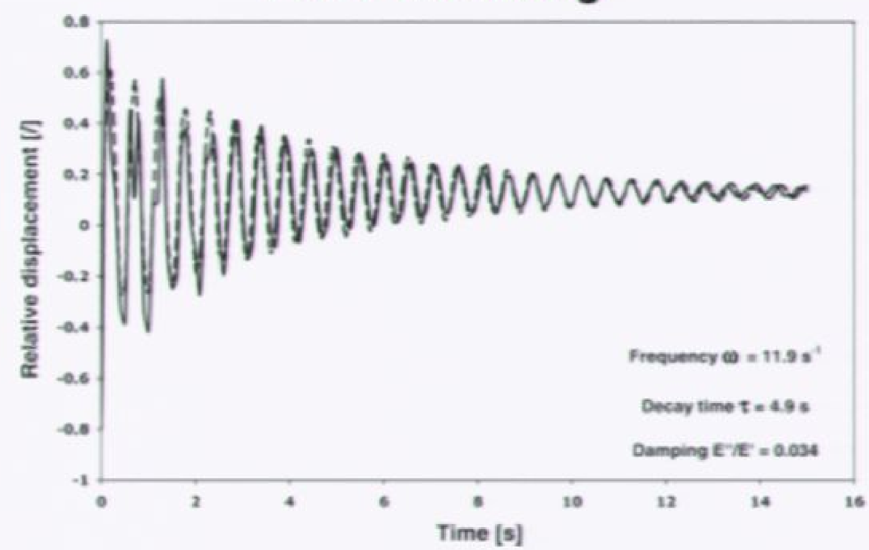

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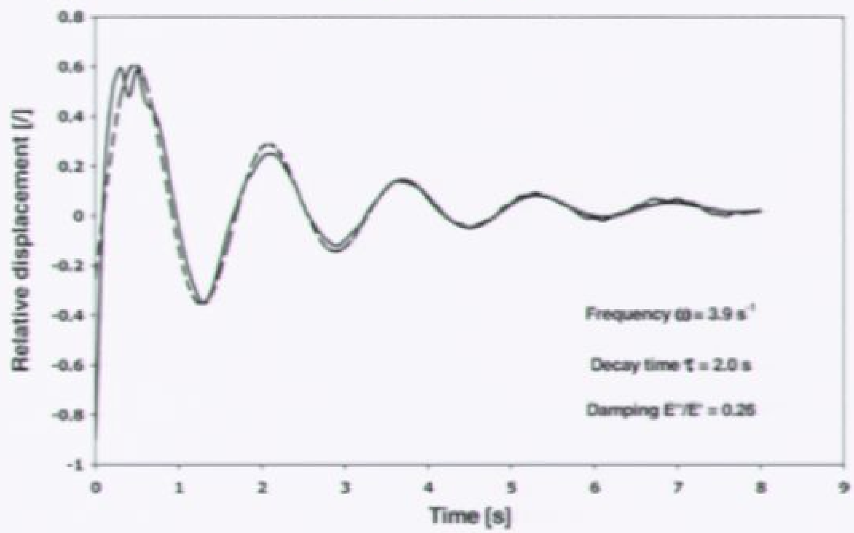

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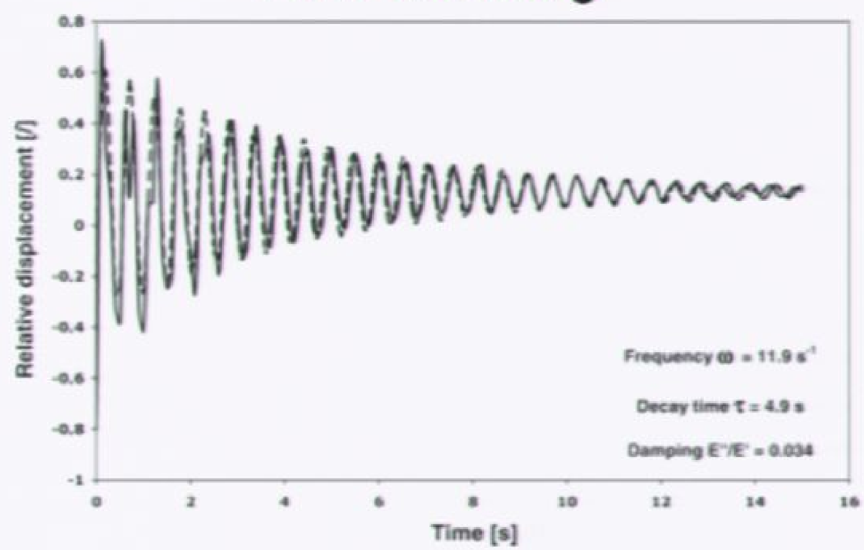

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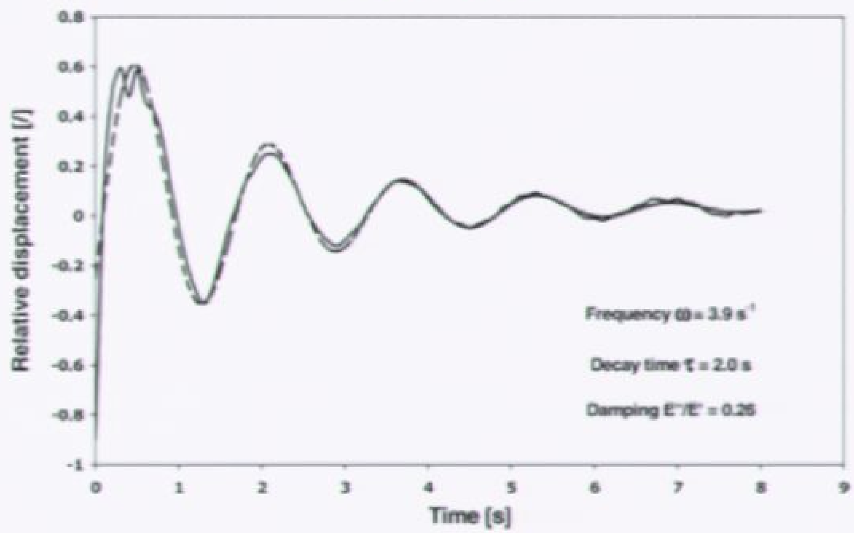

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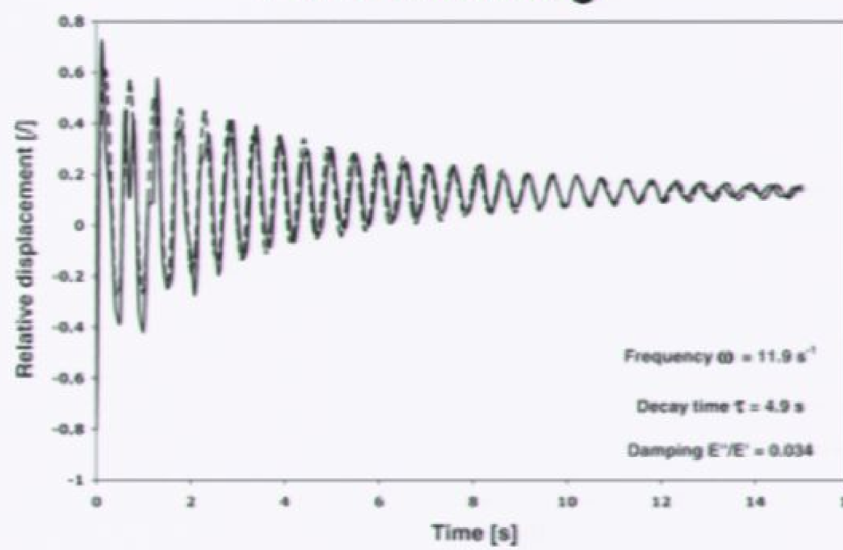

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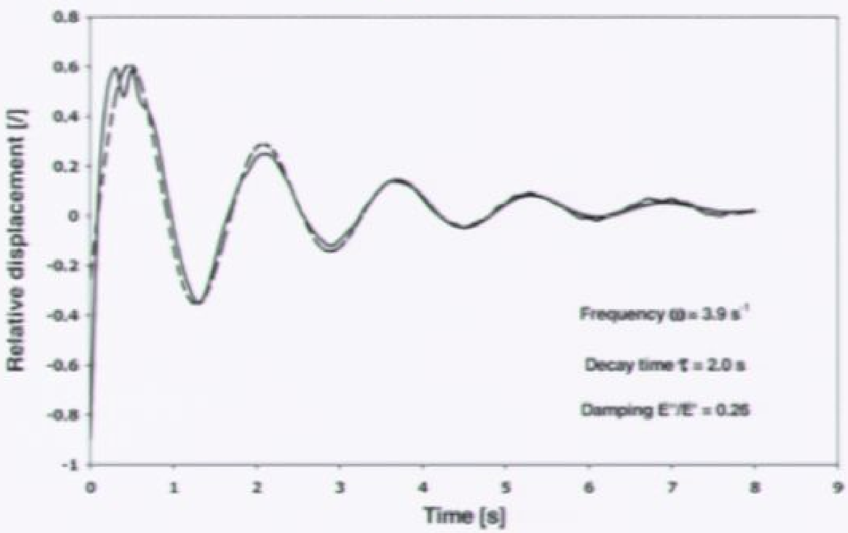

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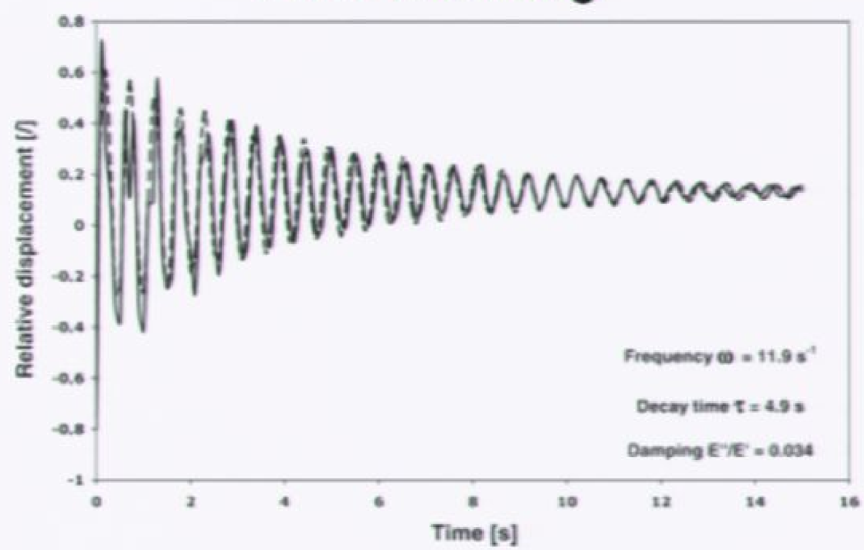

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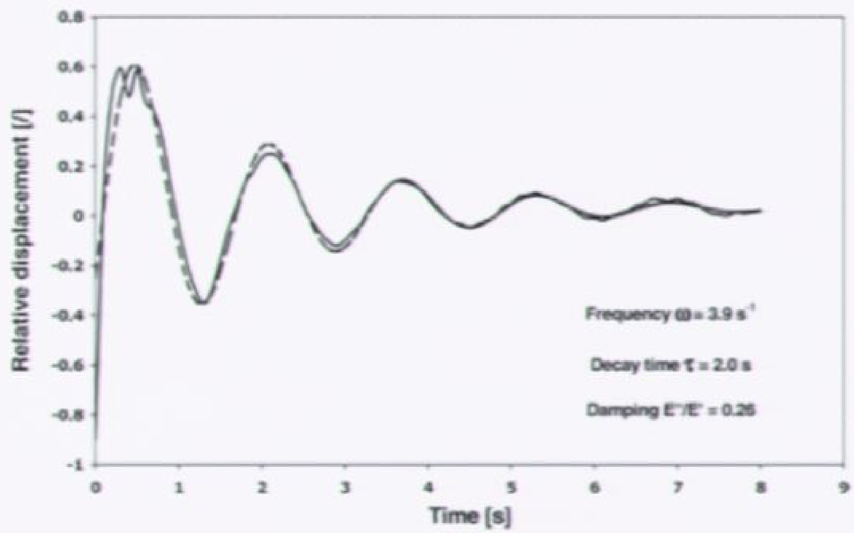

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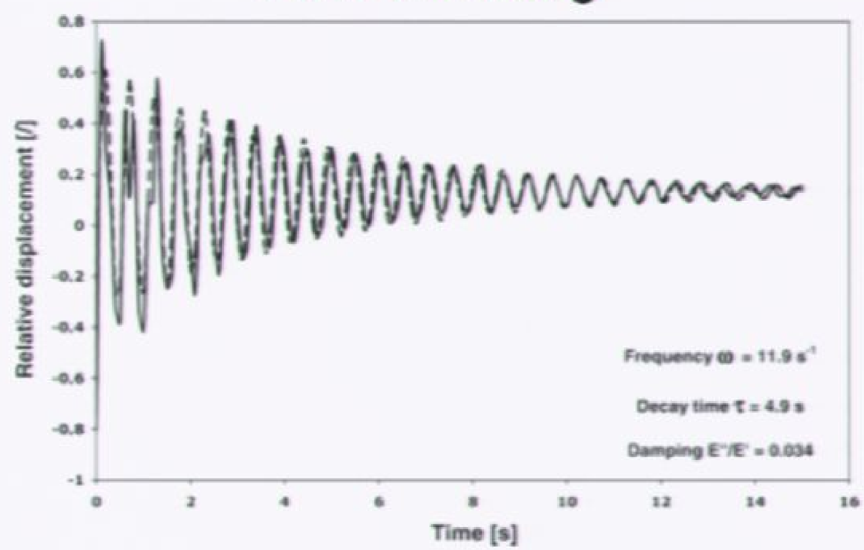

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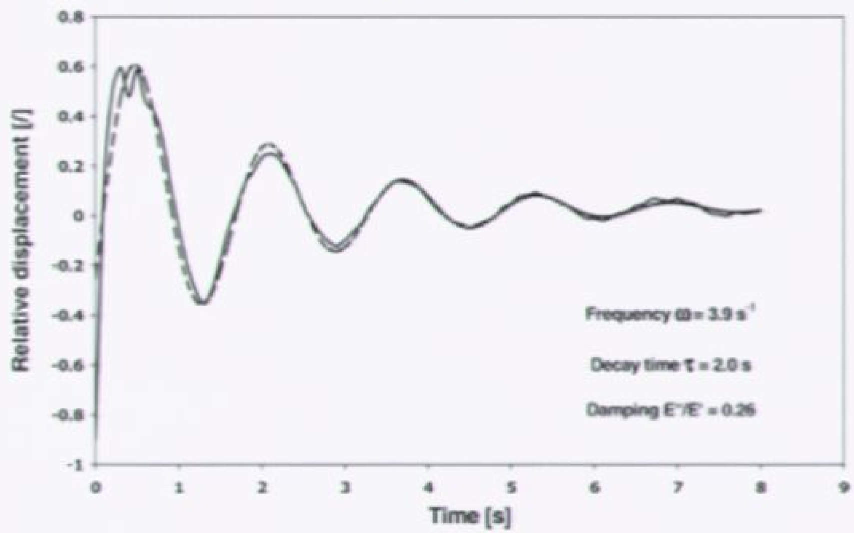

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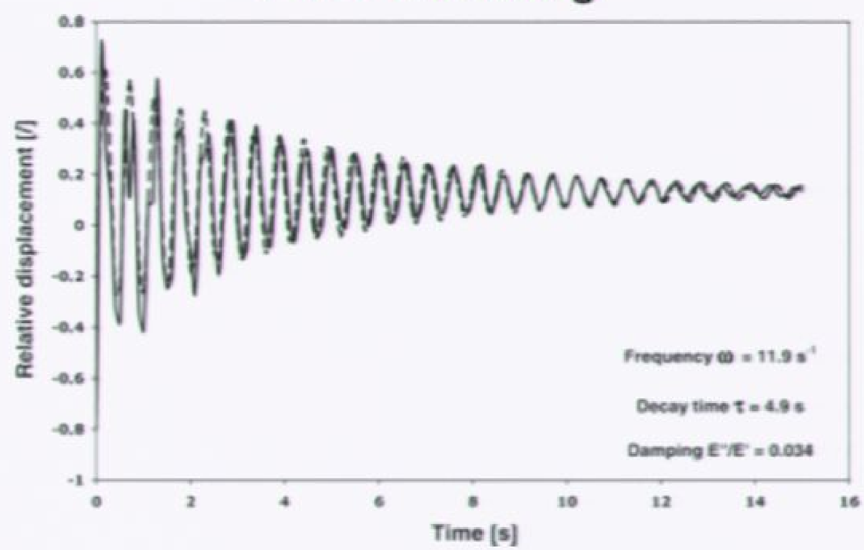

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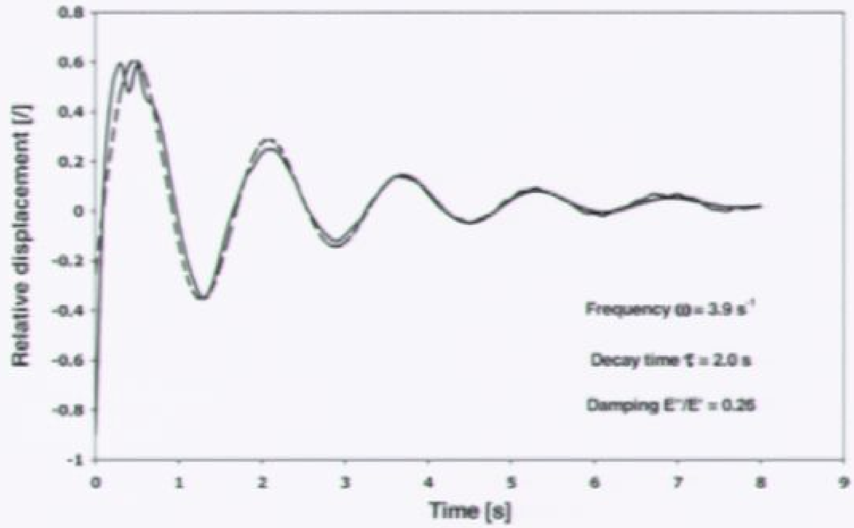

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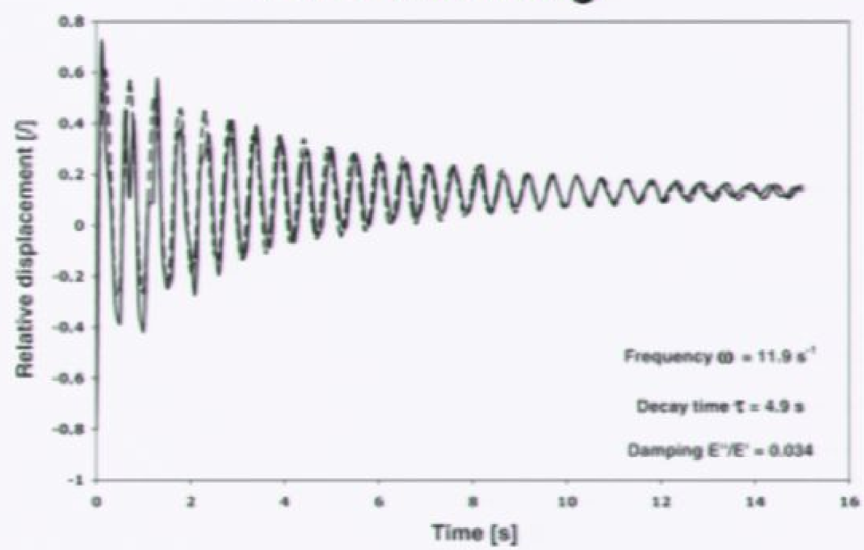

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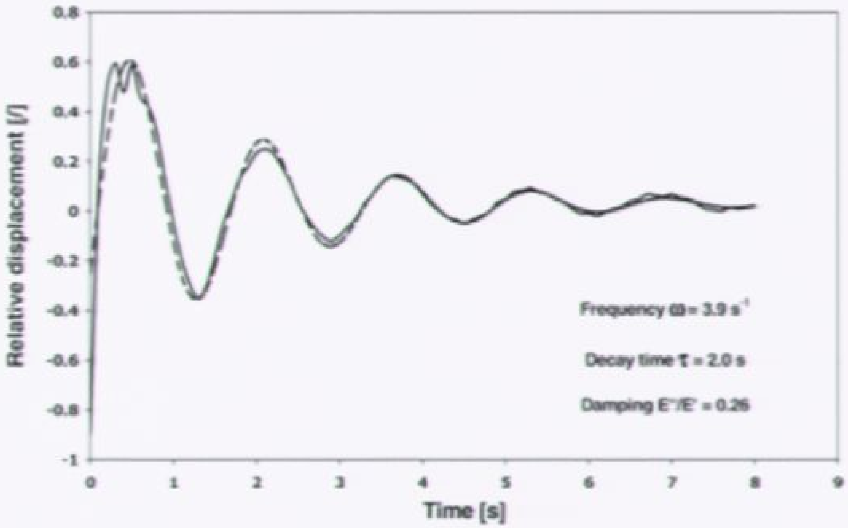

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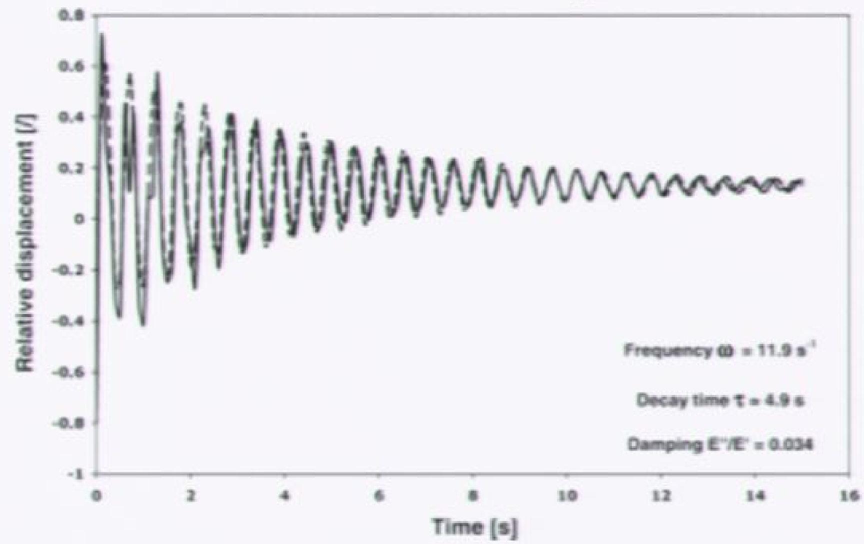

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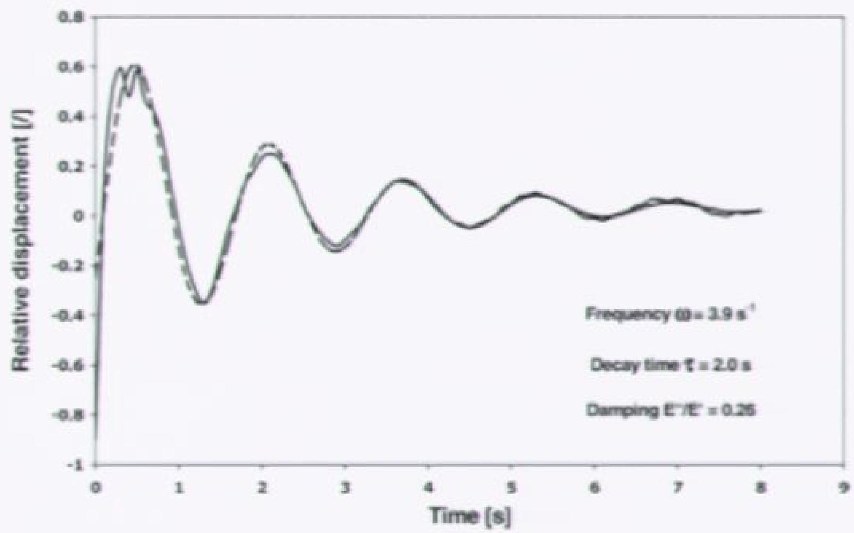

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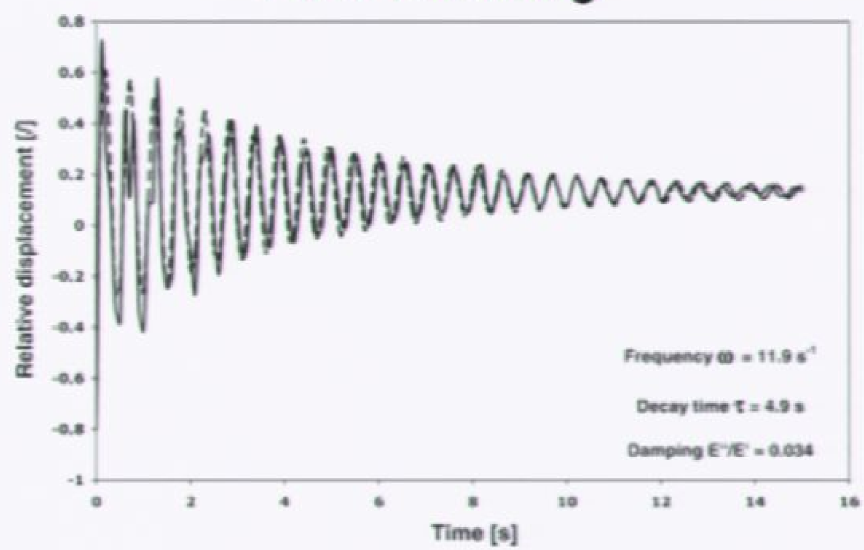

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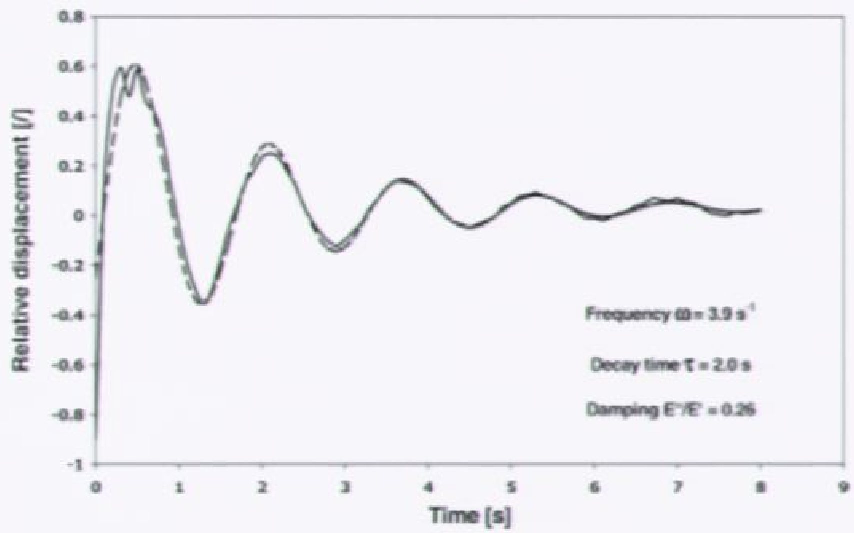

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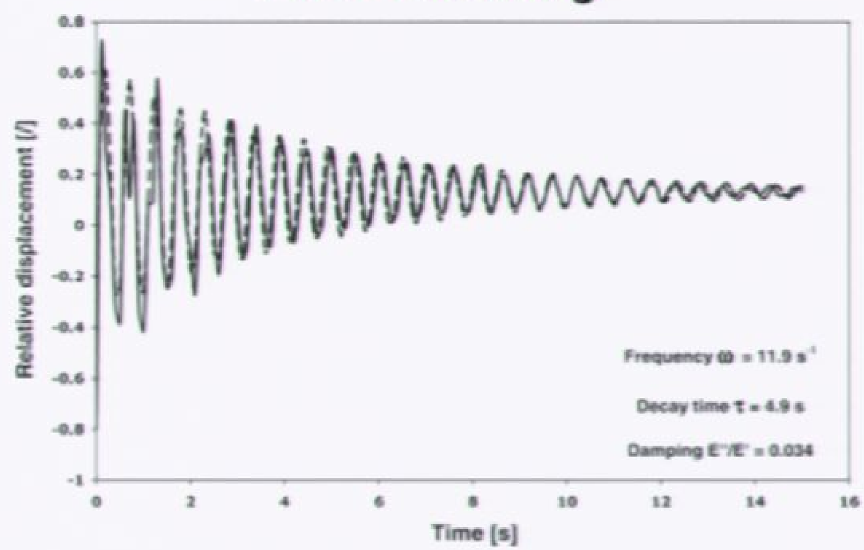

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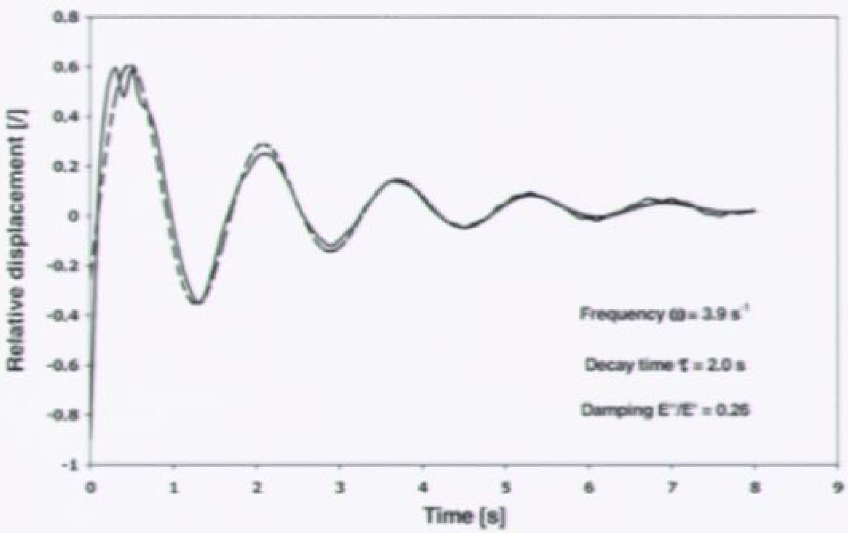

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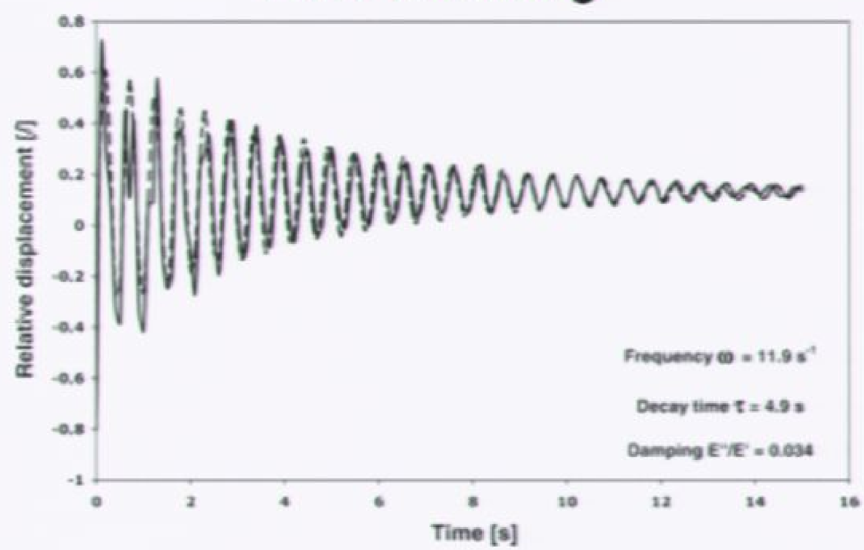

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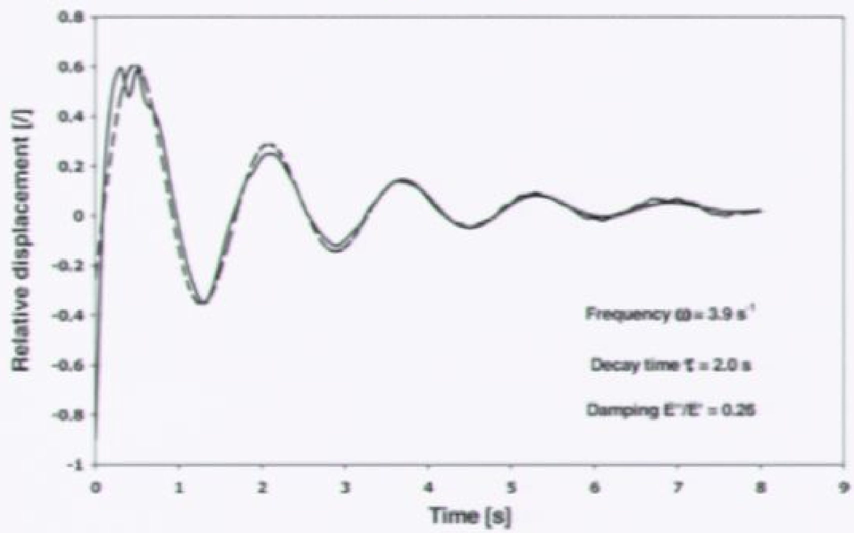

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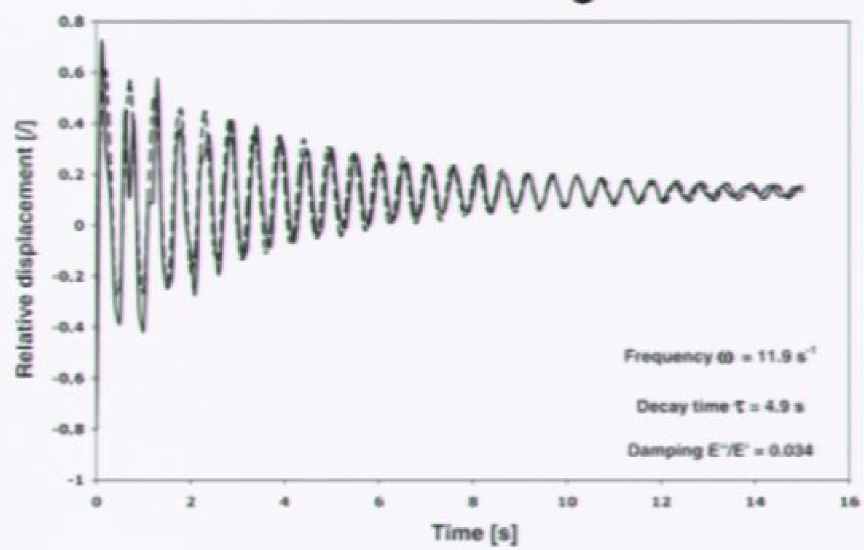

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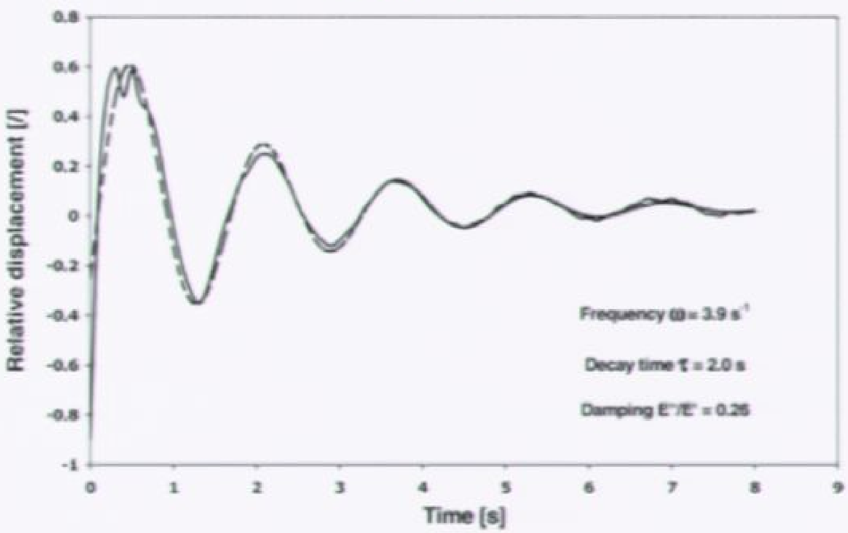

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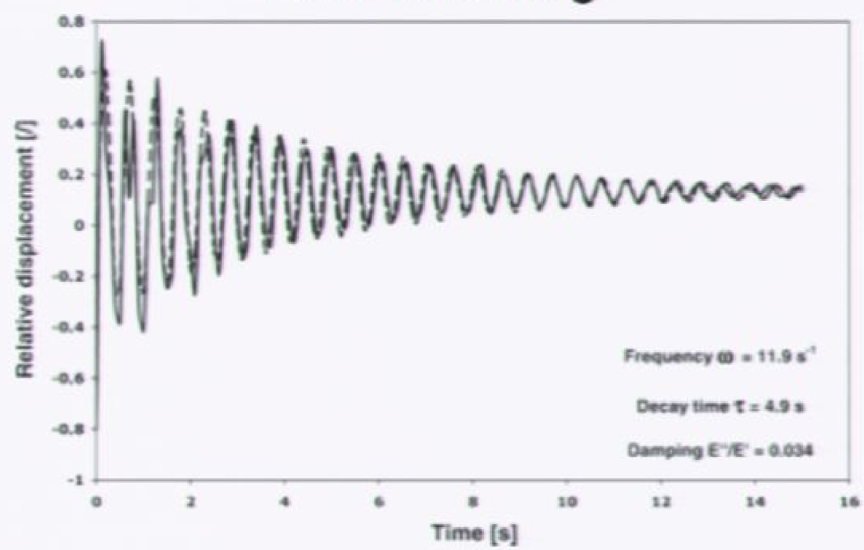

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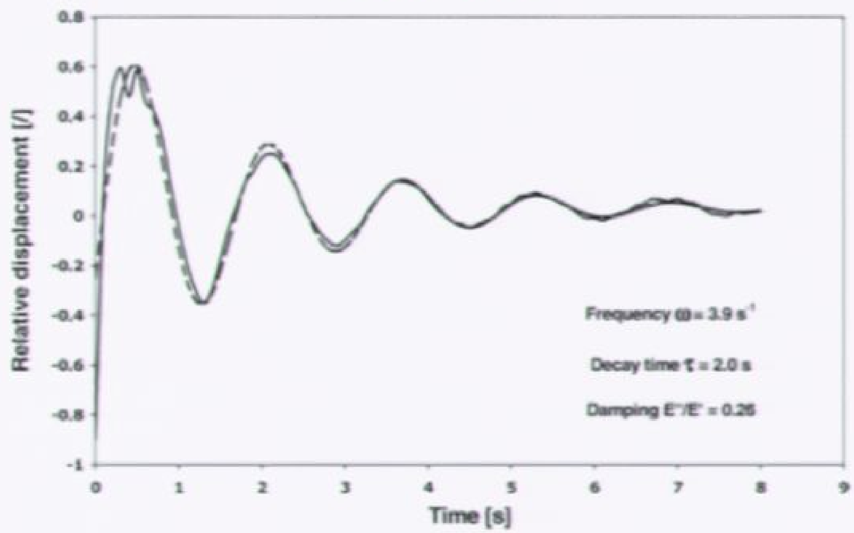

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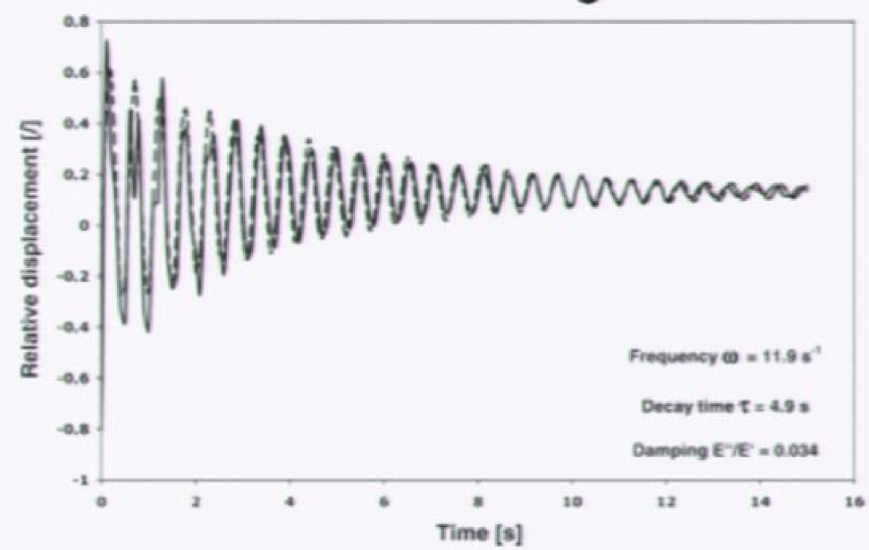

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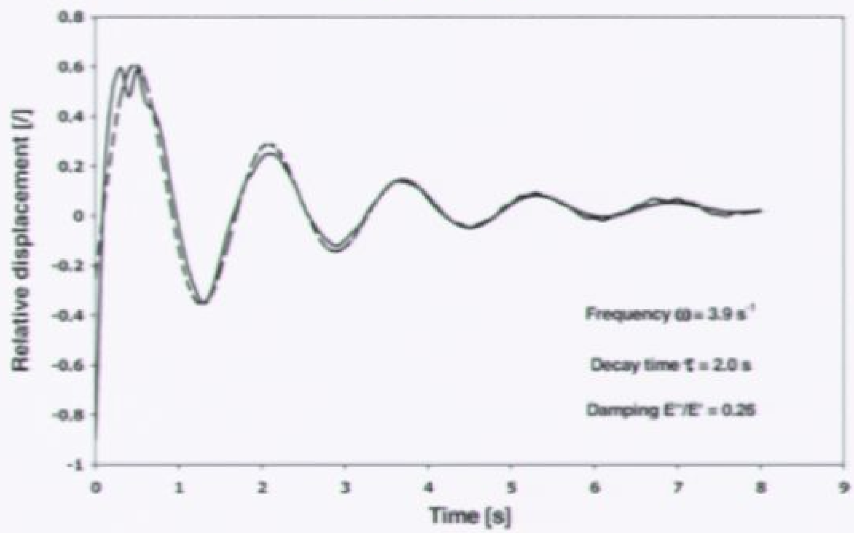

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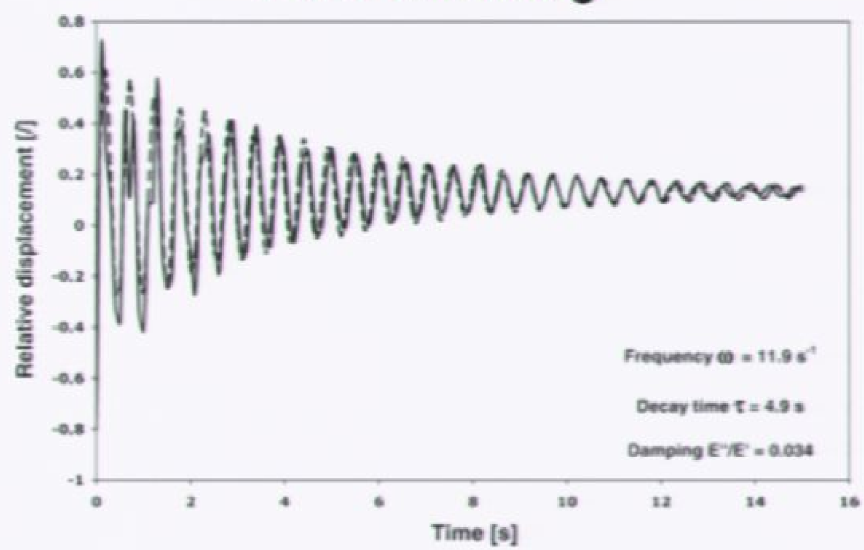

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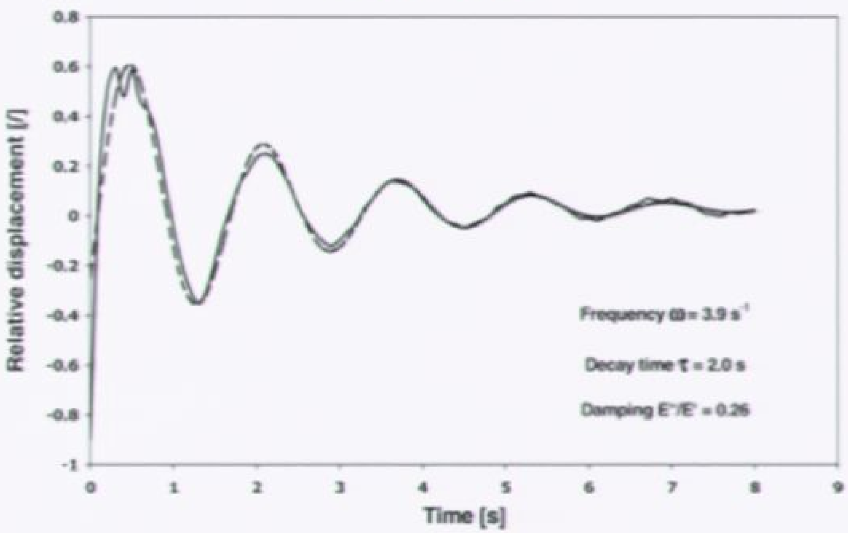

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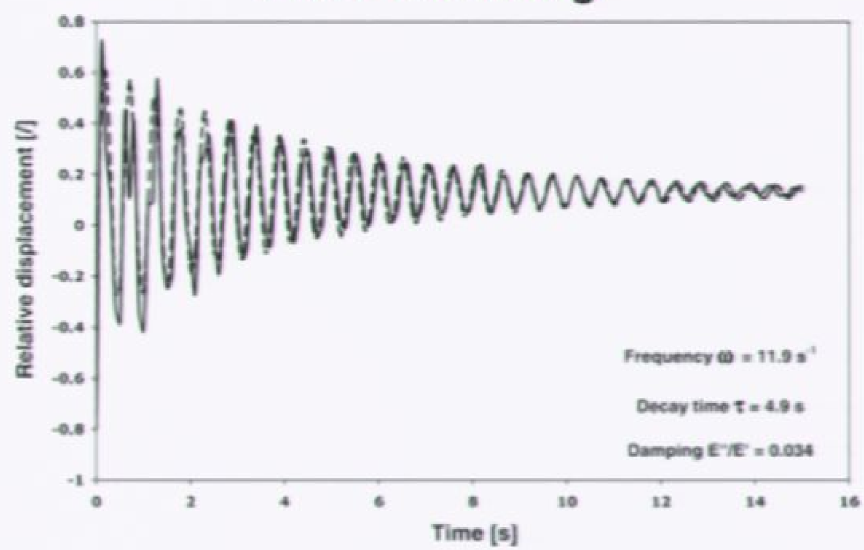

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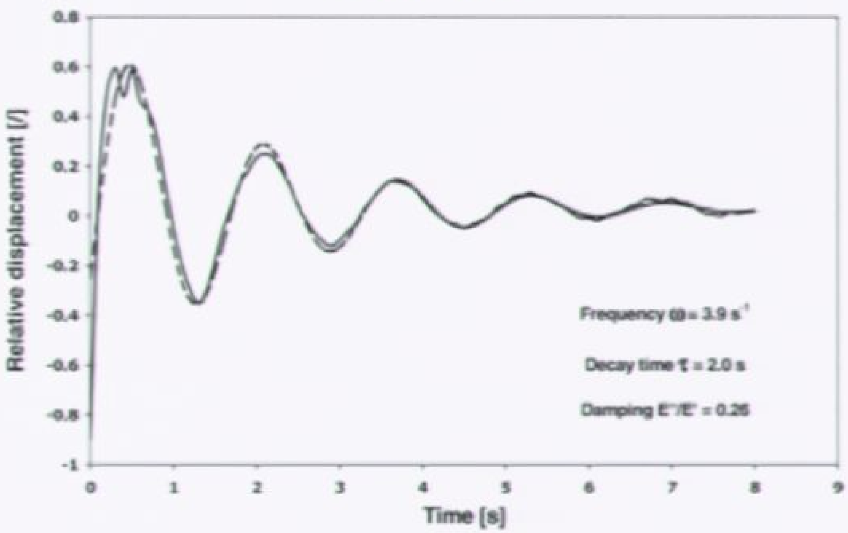

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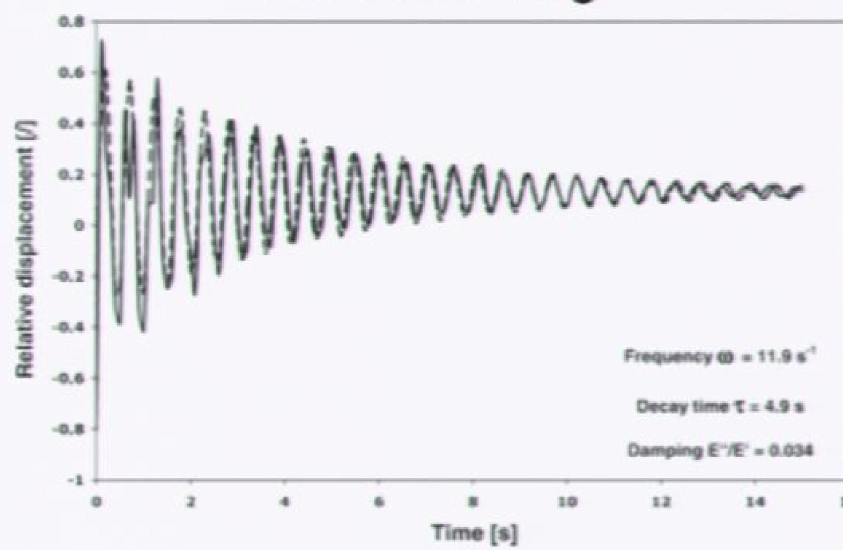

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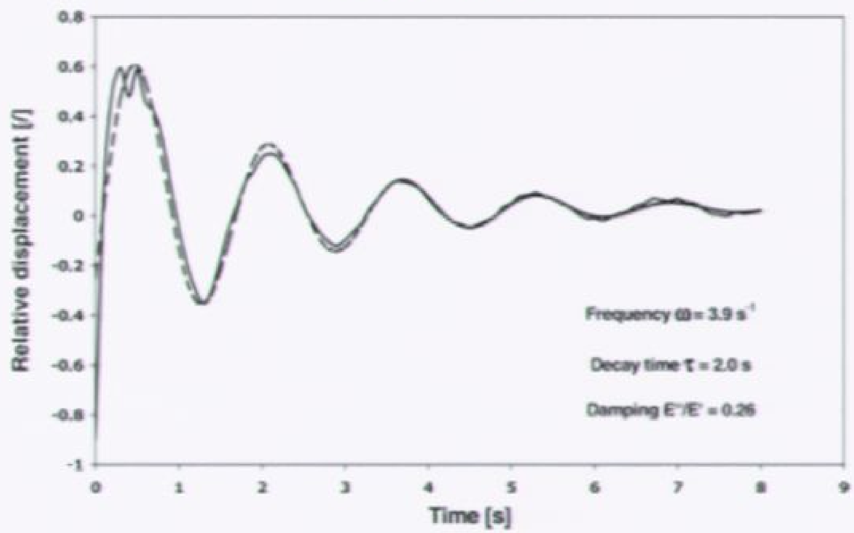

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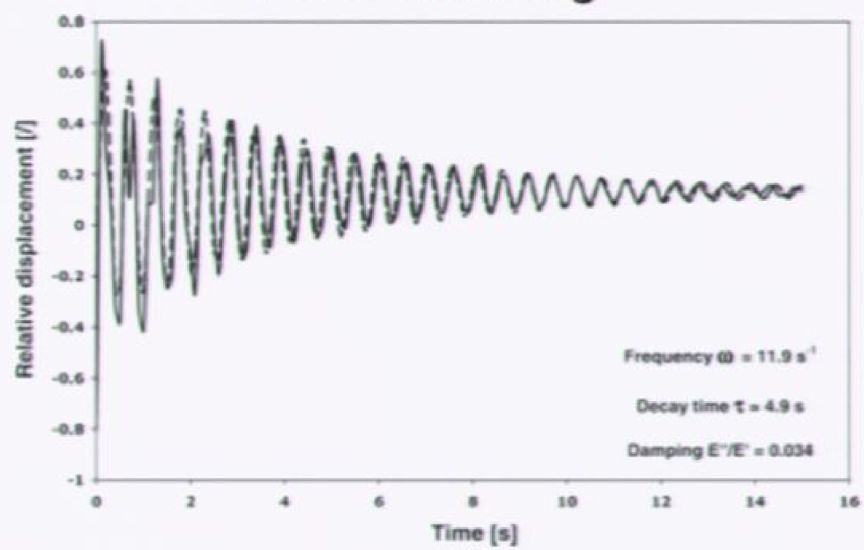

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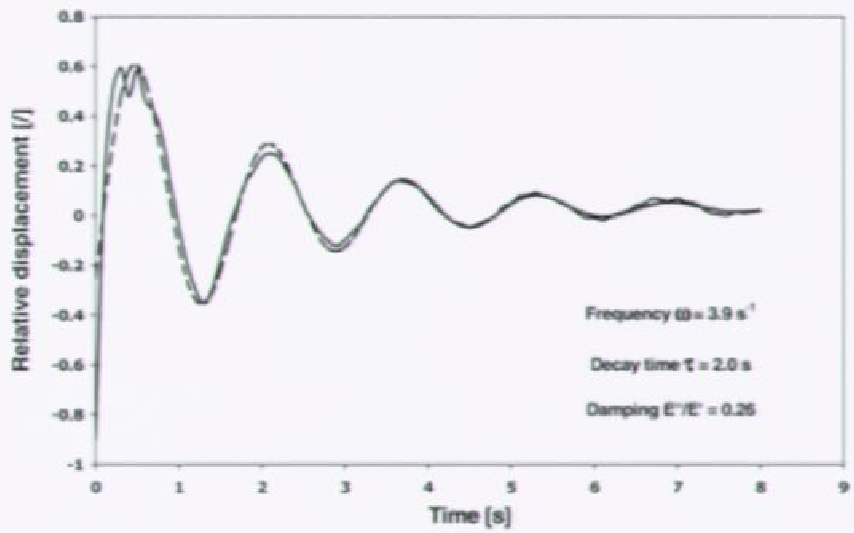

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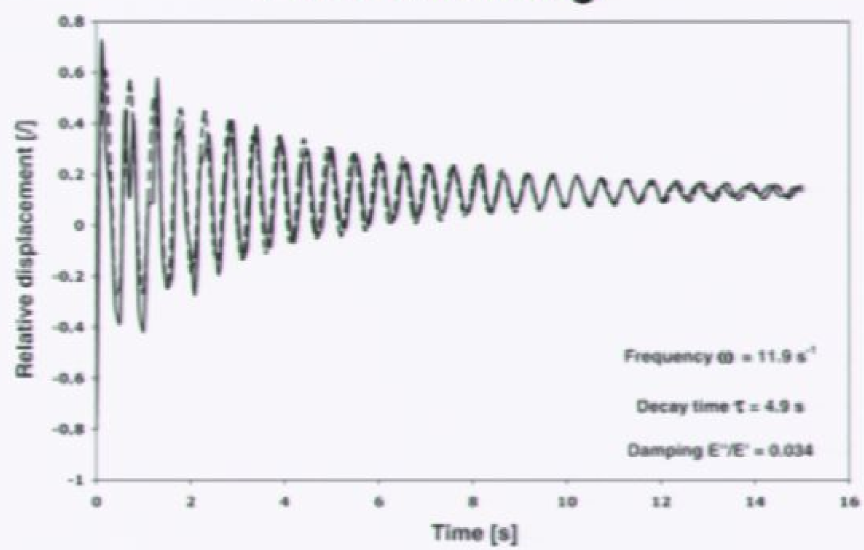

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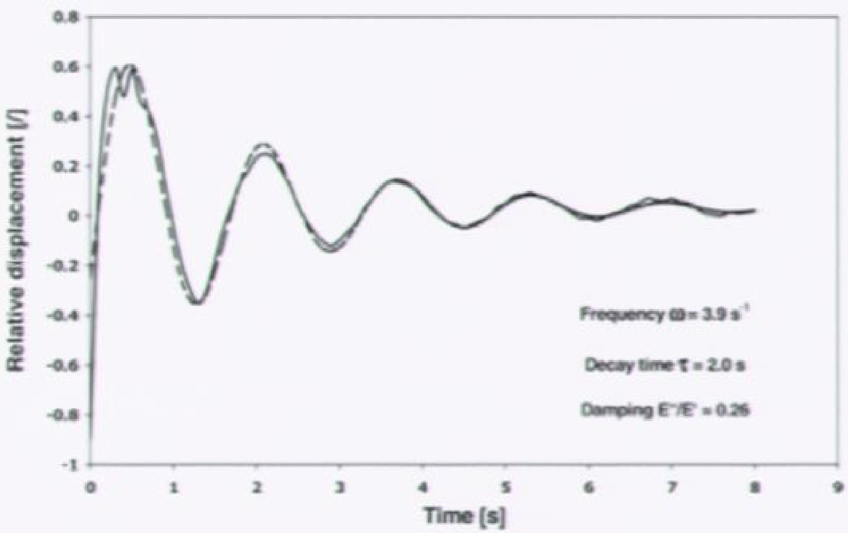

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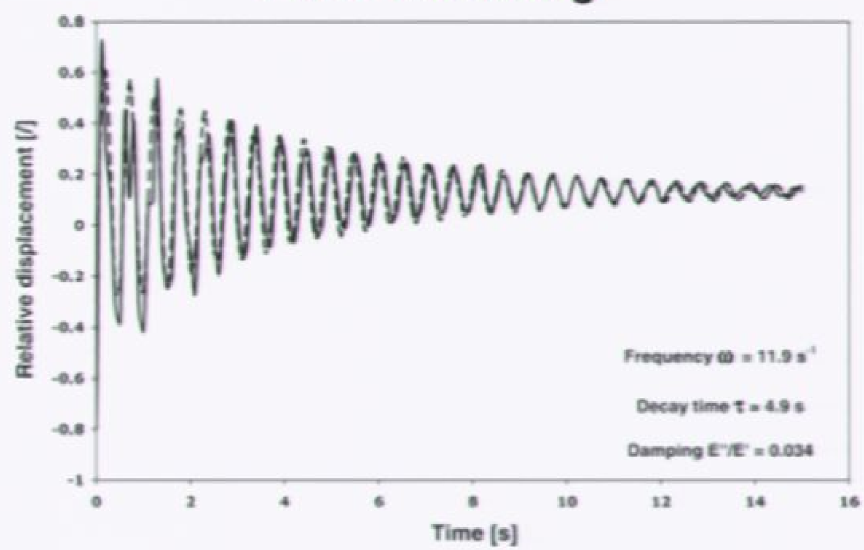

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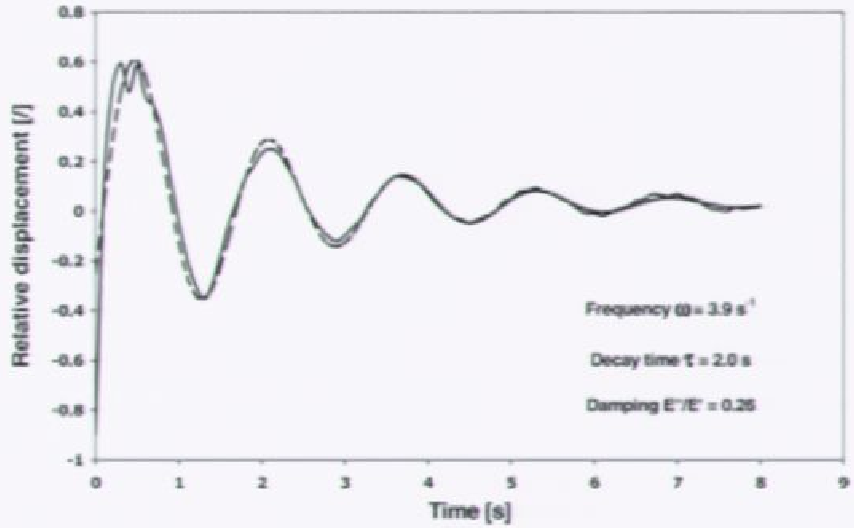

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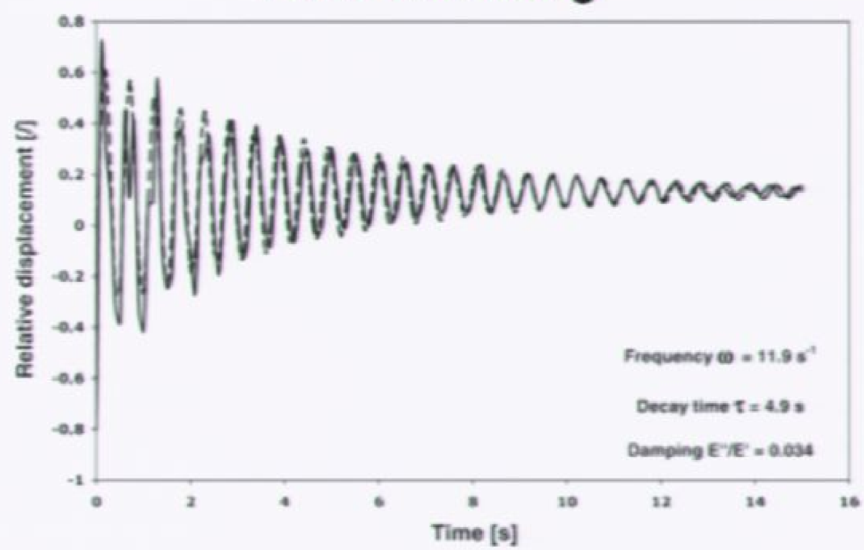

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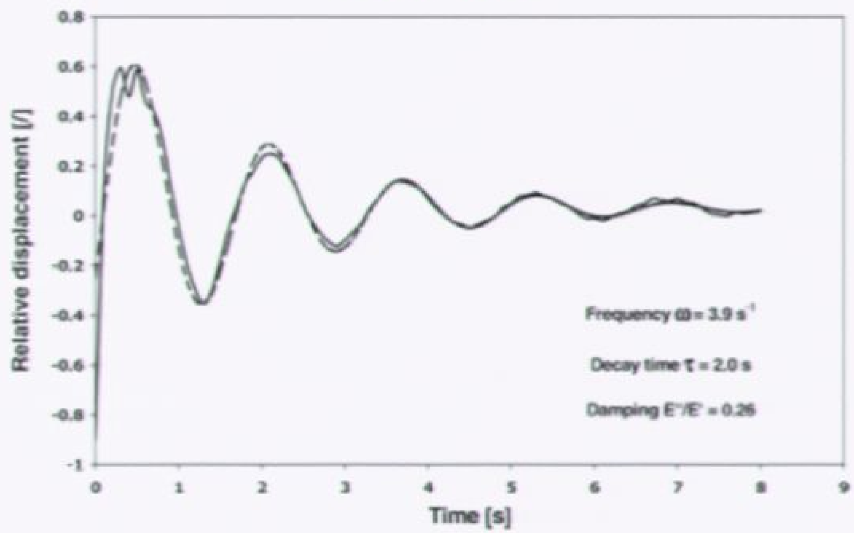

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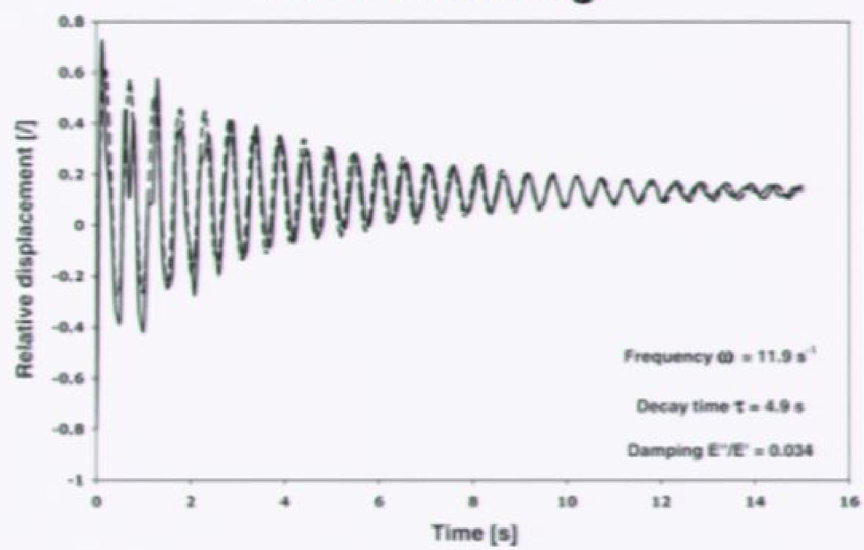

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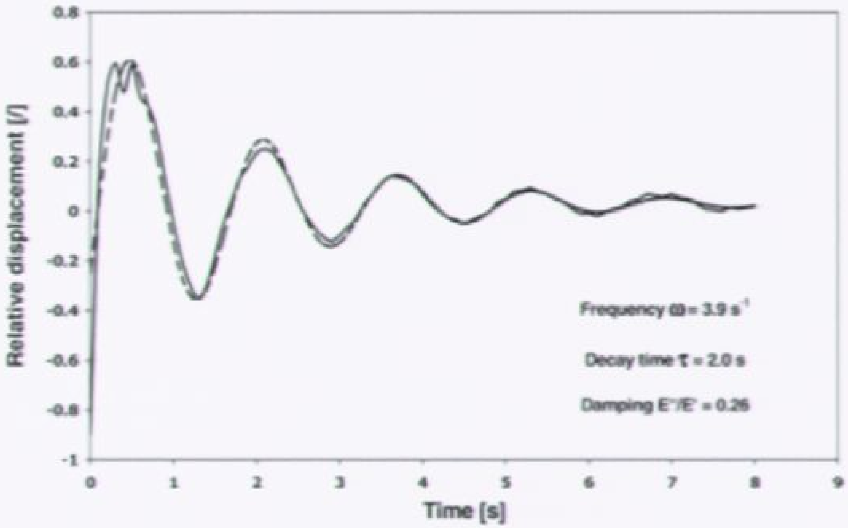
The Douglas Fir

Total Tree



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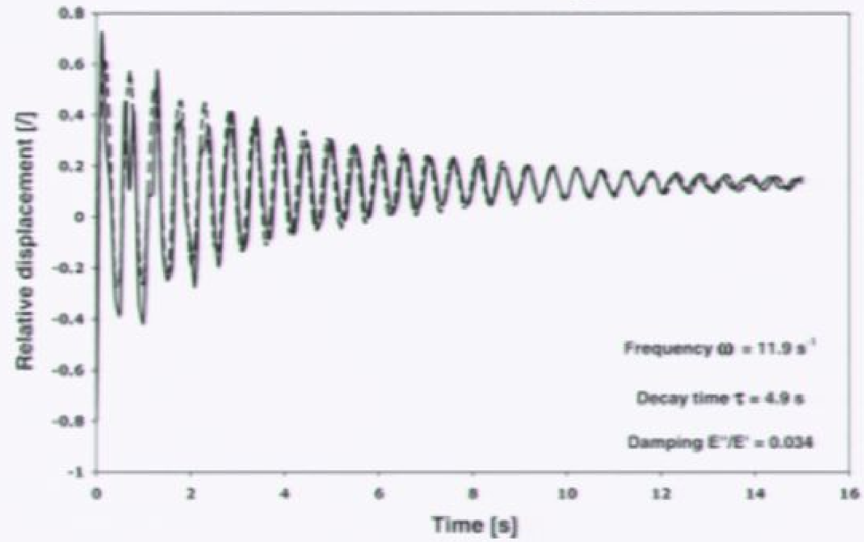

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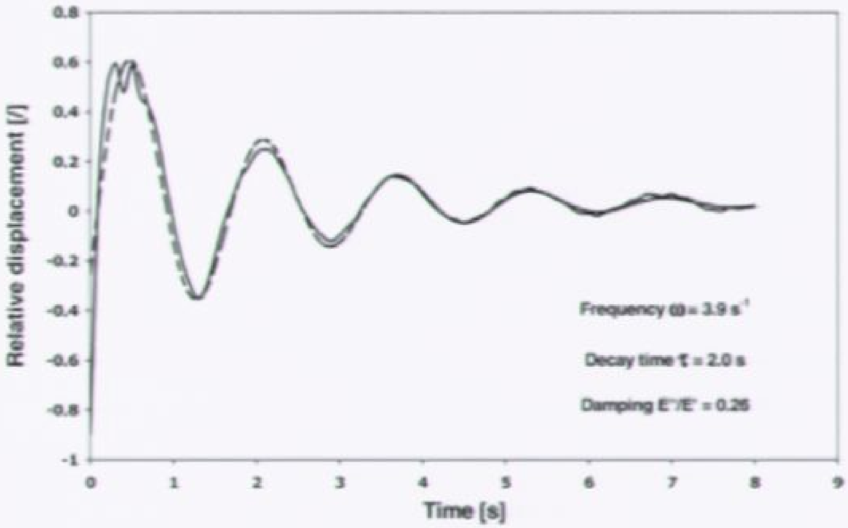

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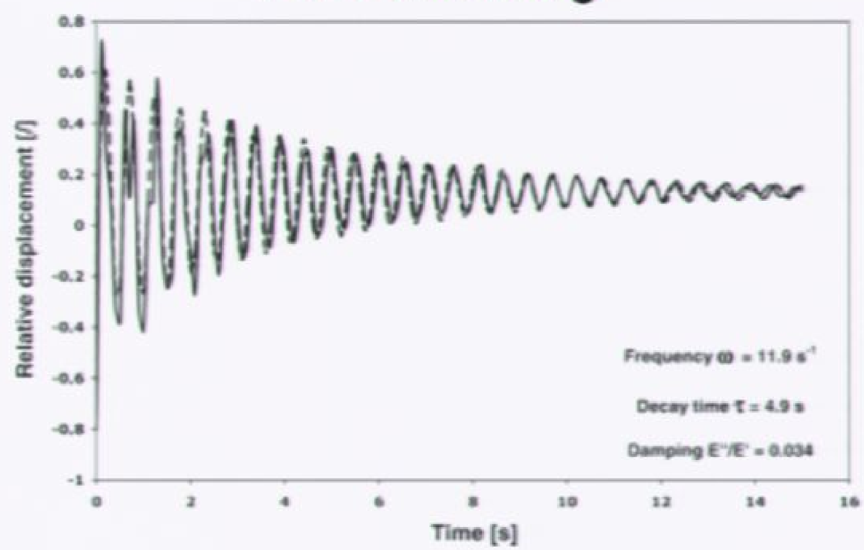

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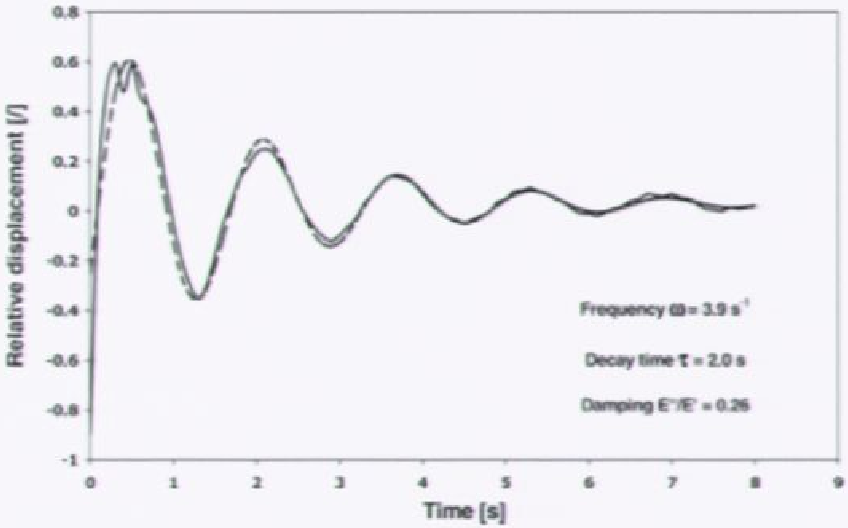

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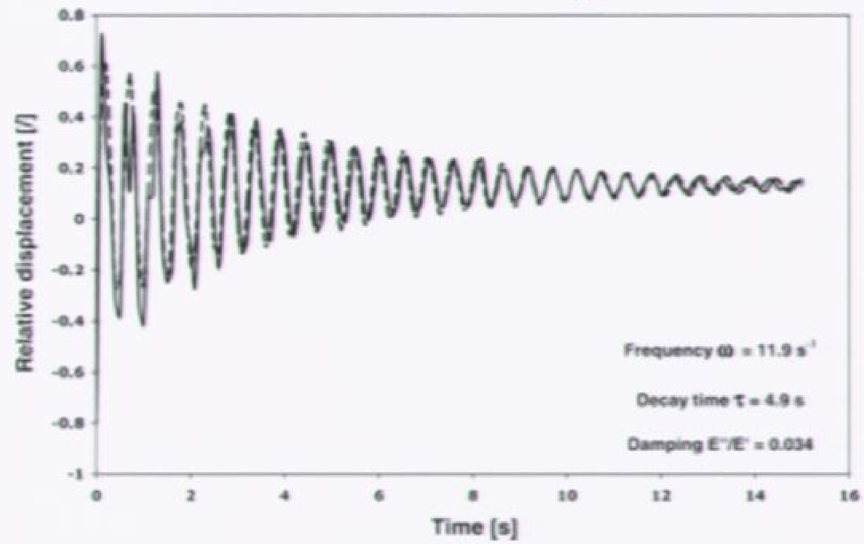

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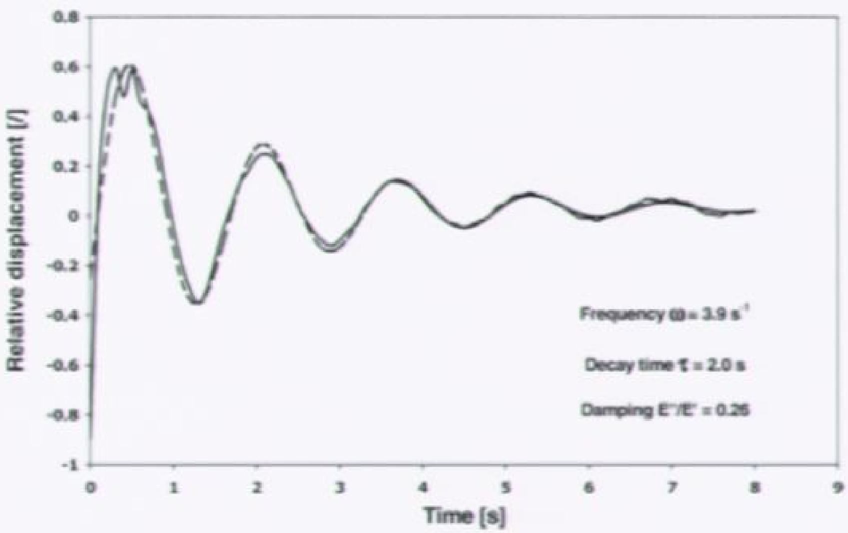

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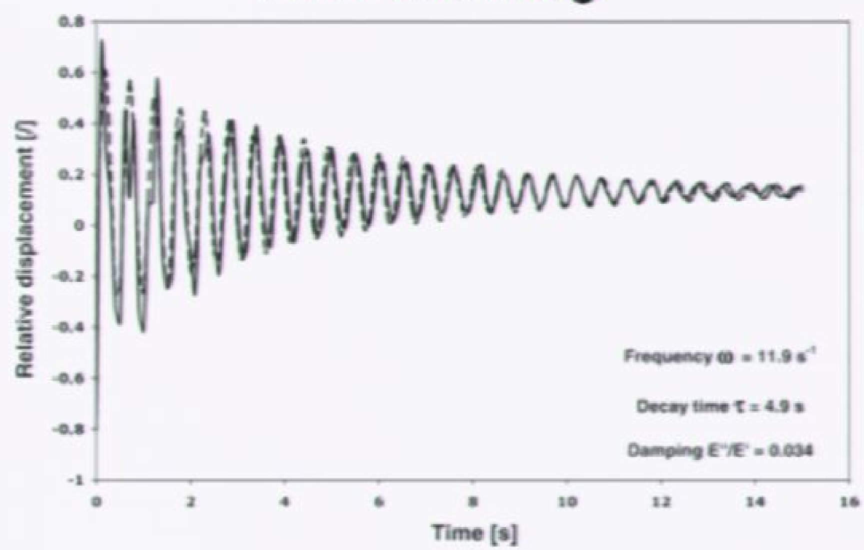

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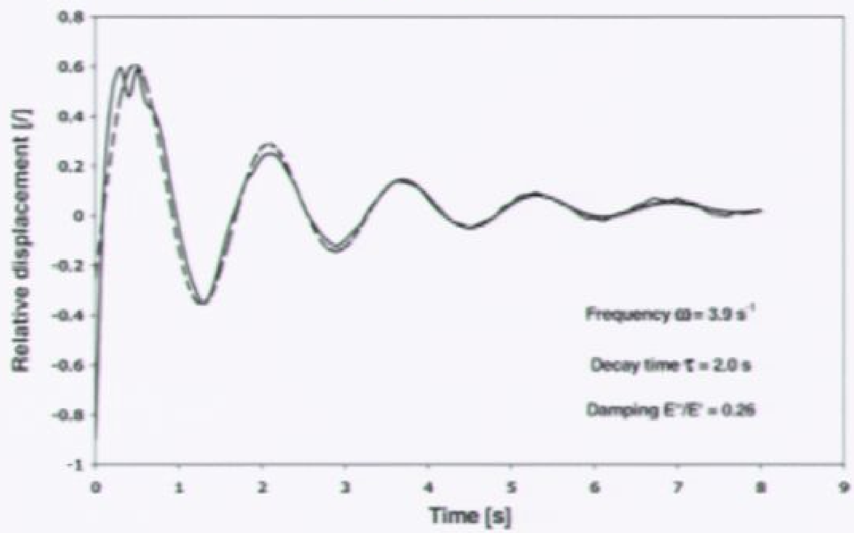

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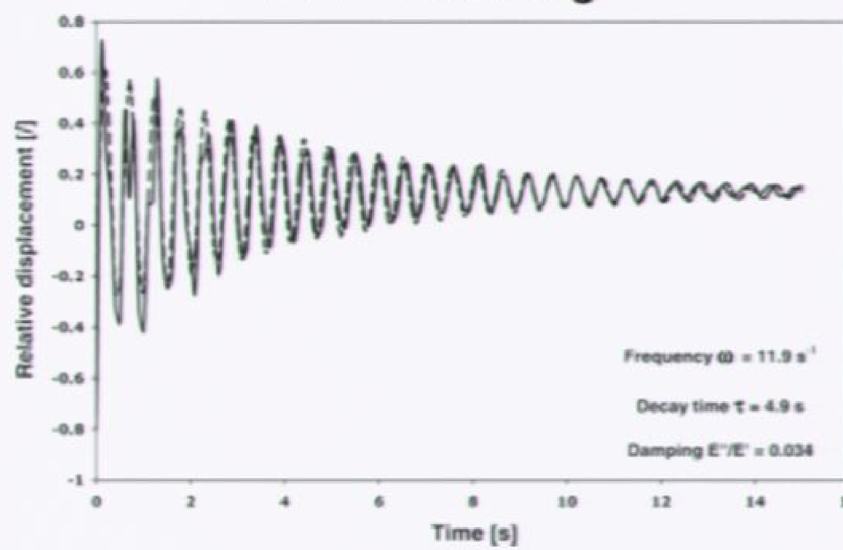

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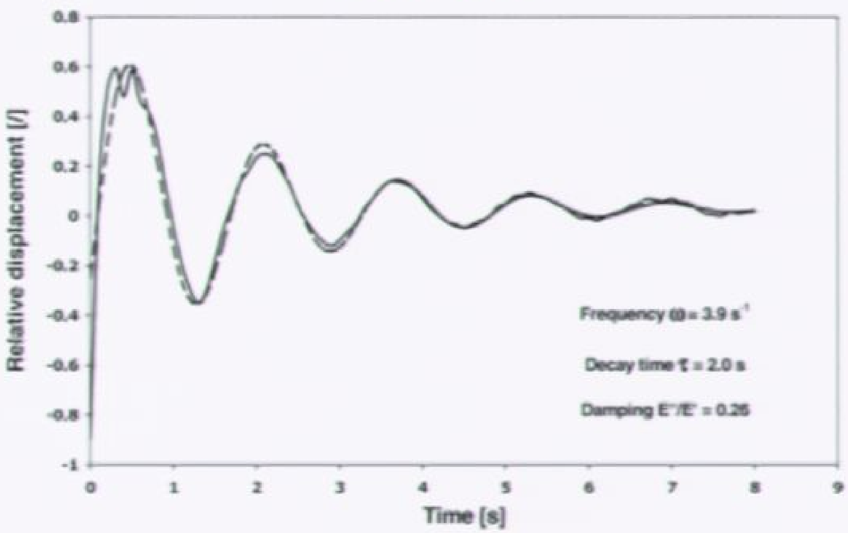

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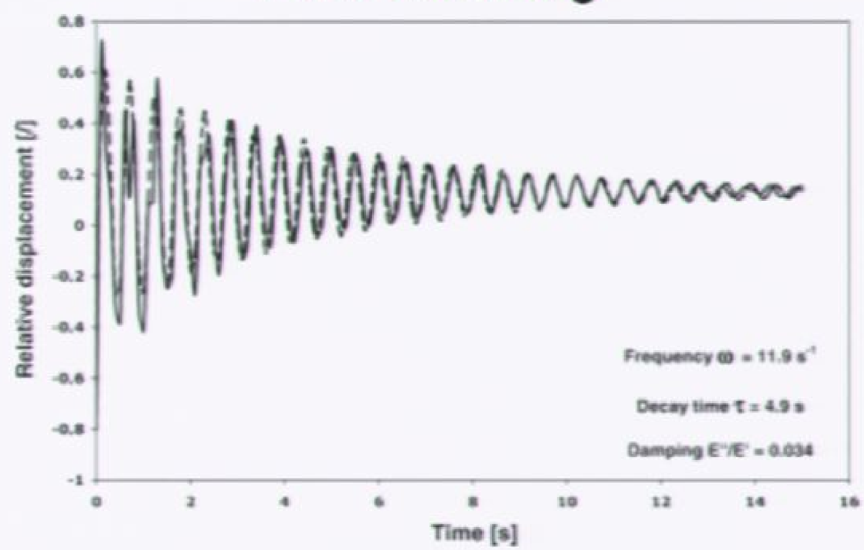

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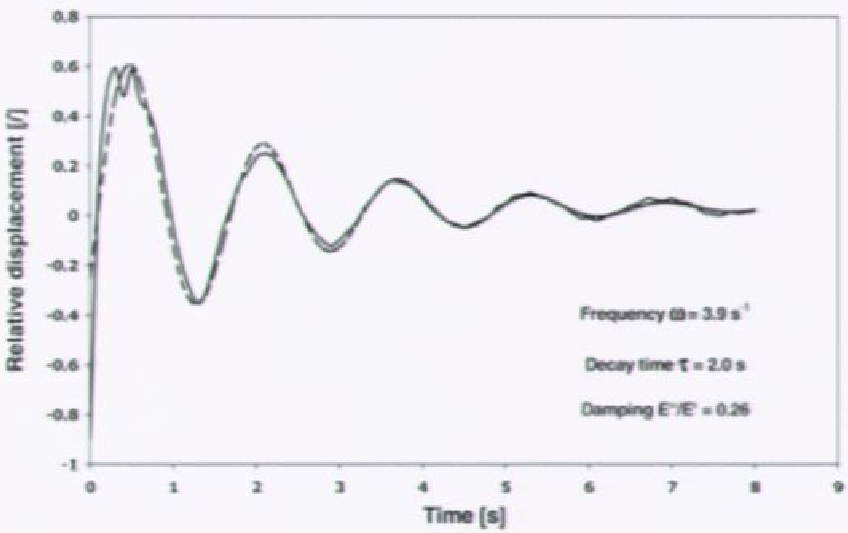

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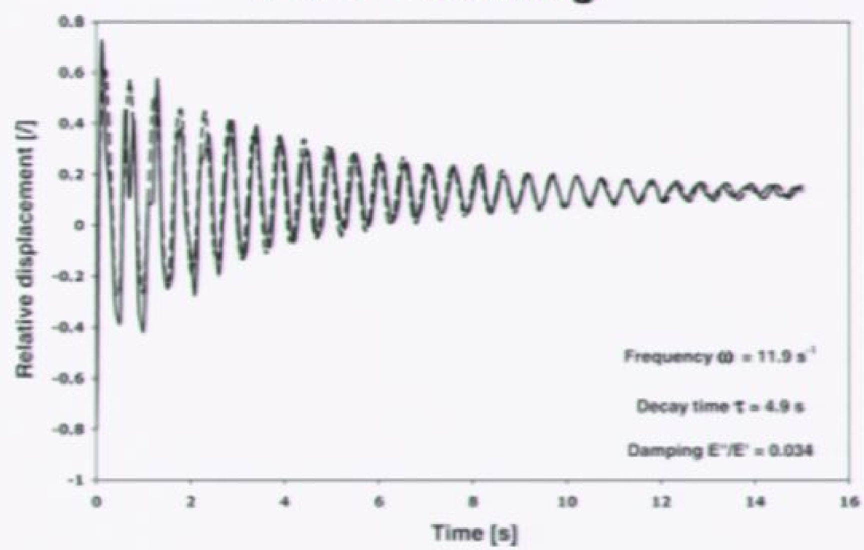

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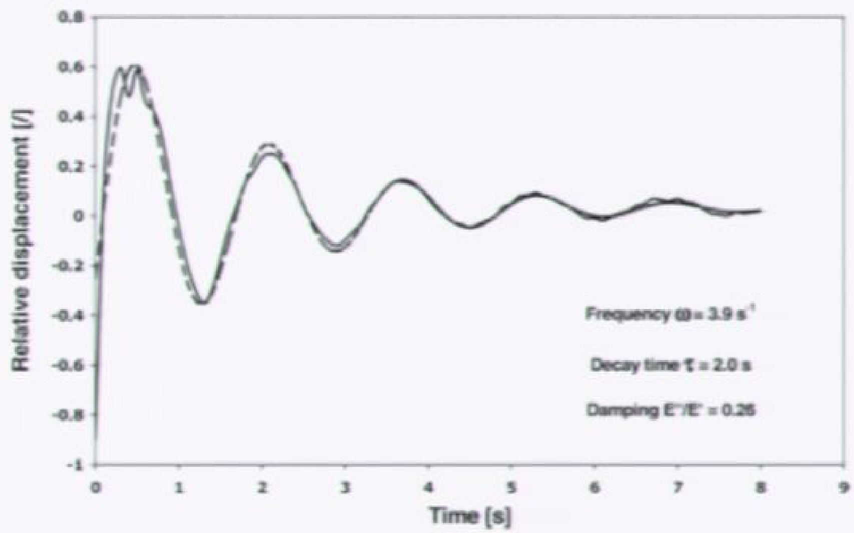

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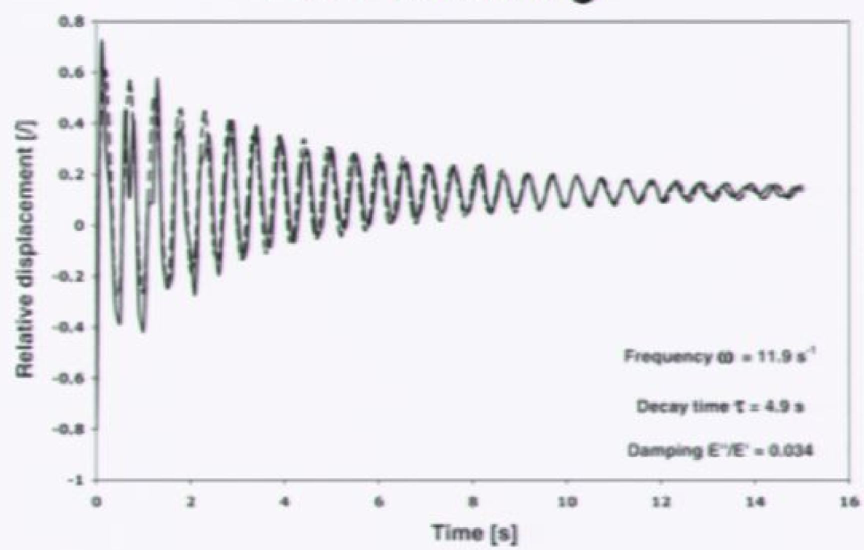

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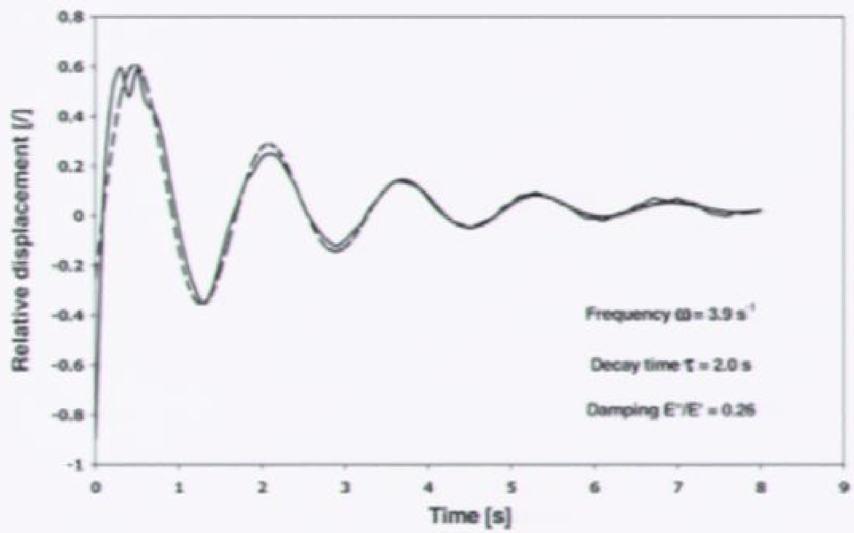

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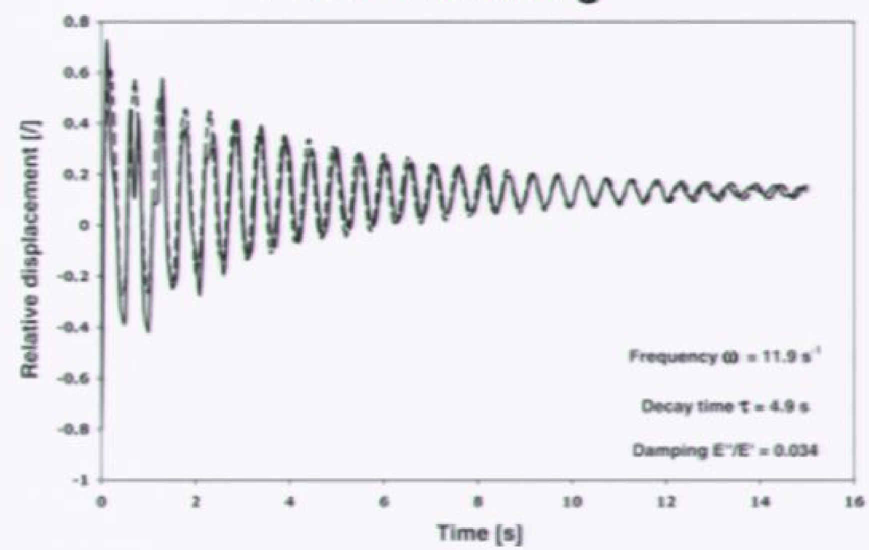

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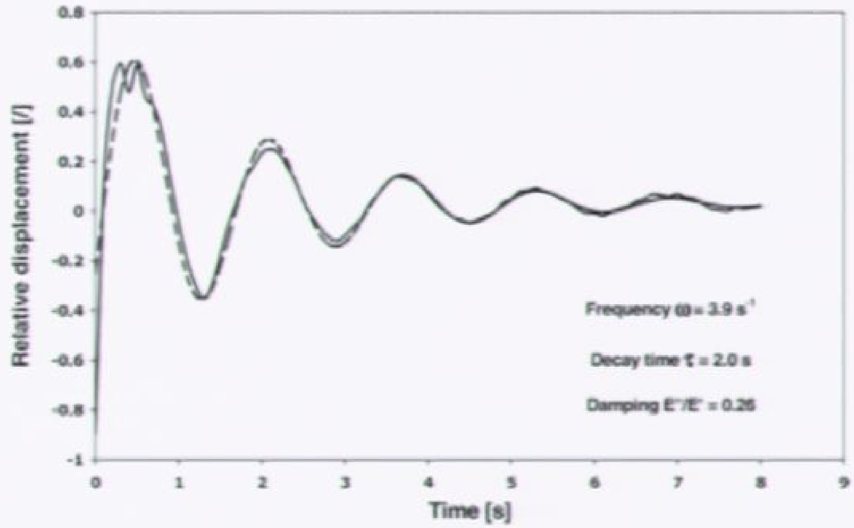

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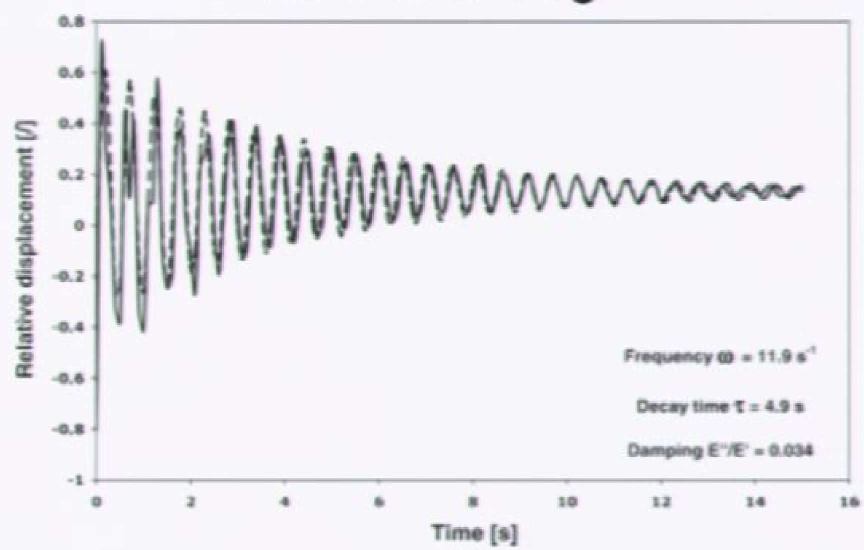

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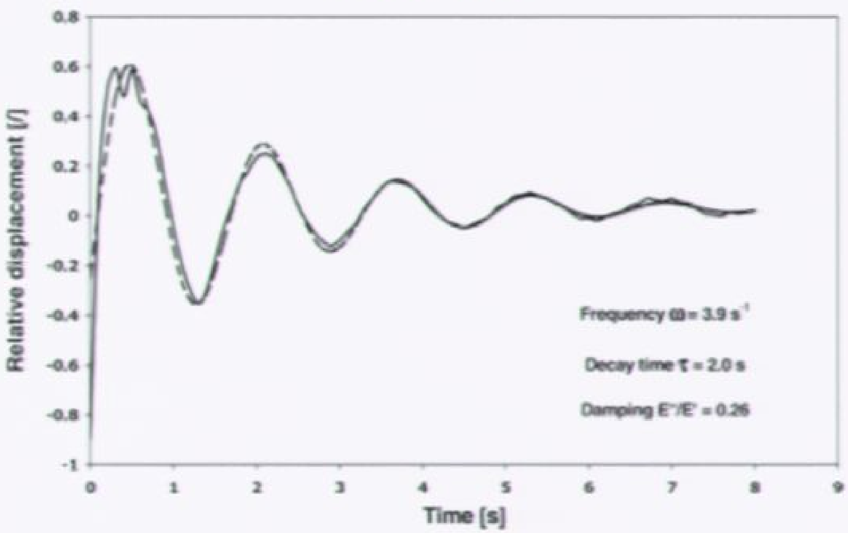

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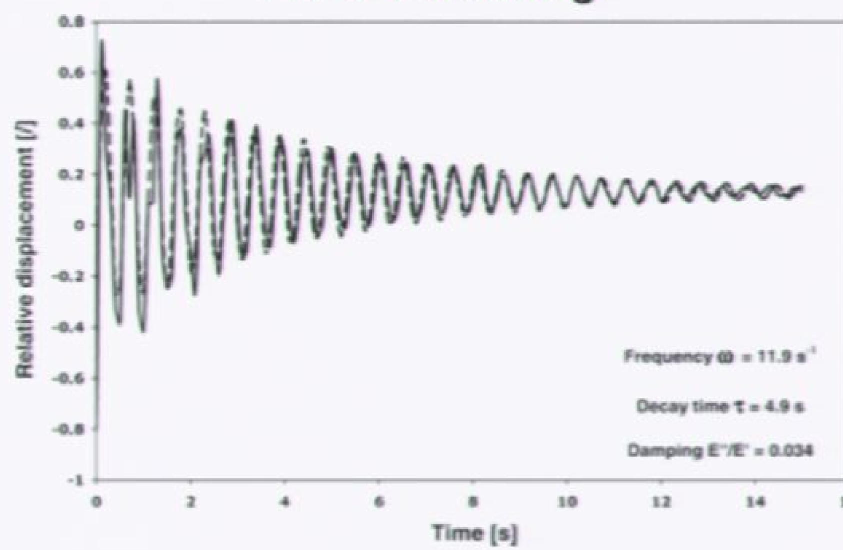

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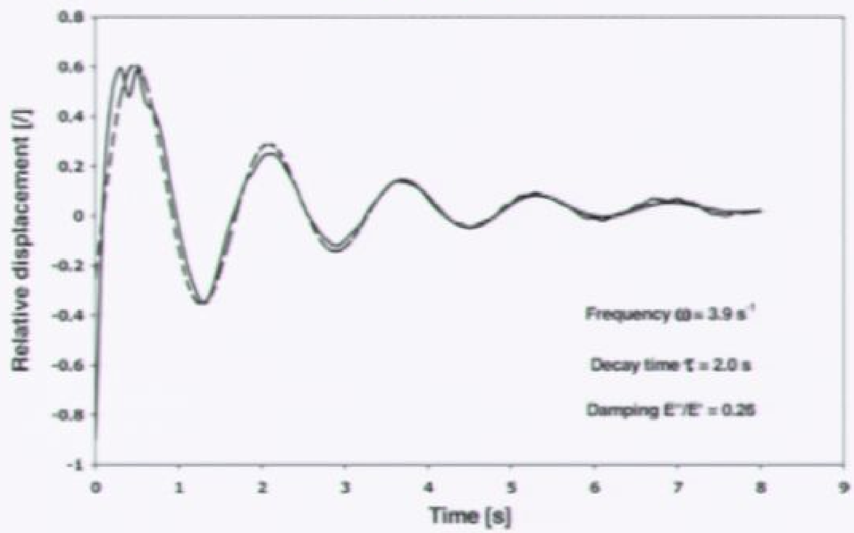

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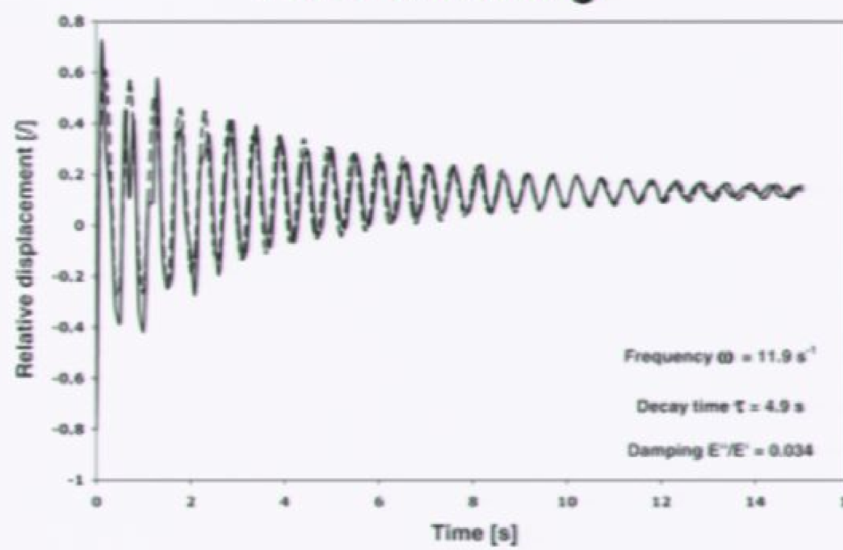

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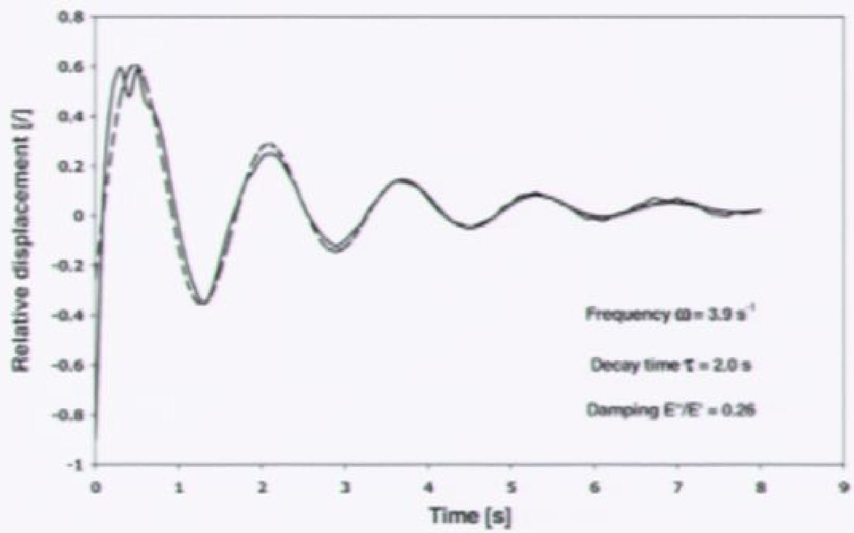

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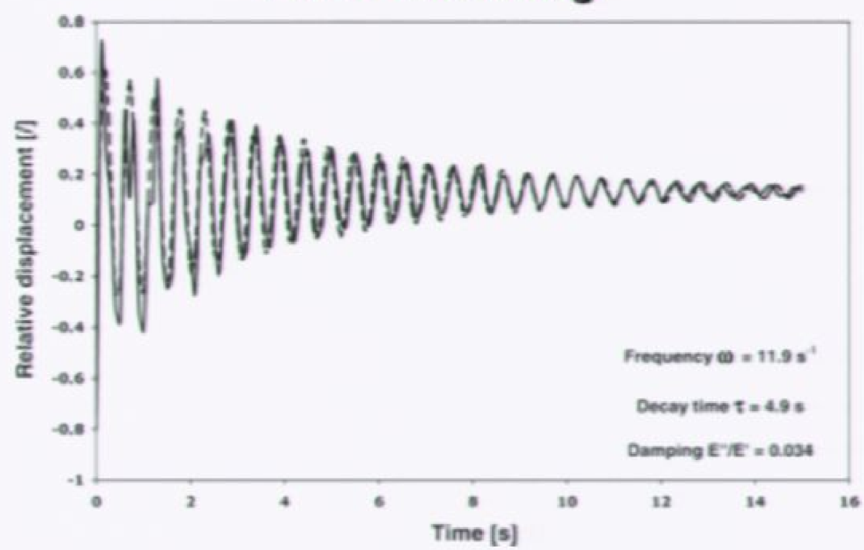

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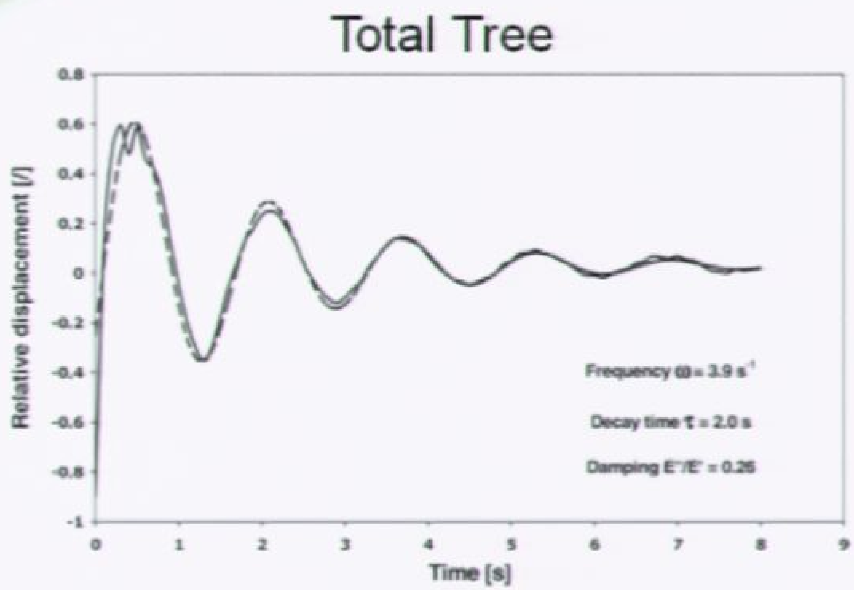

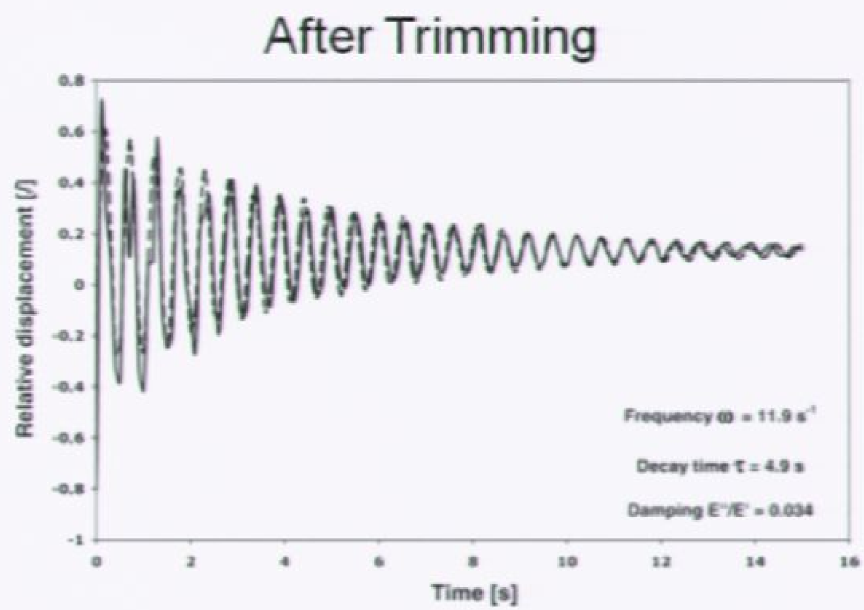

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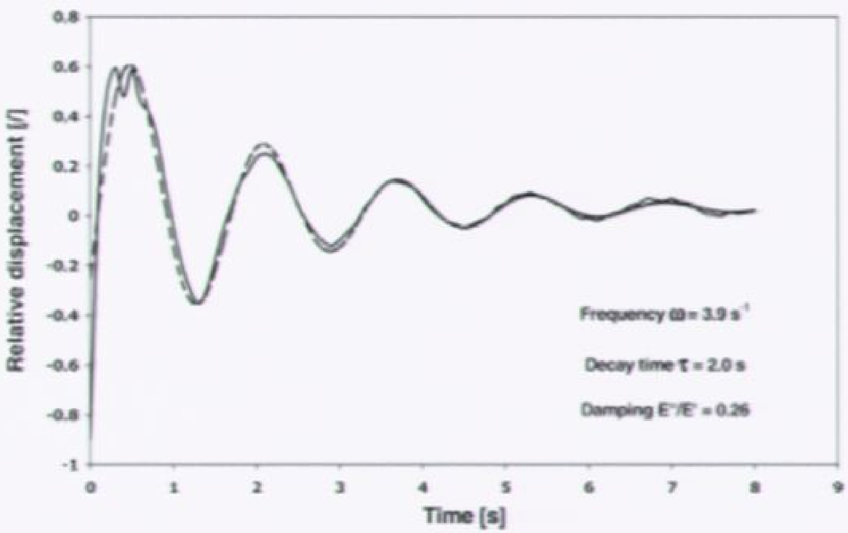

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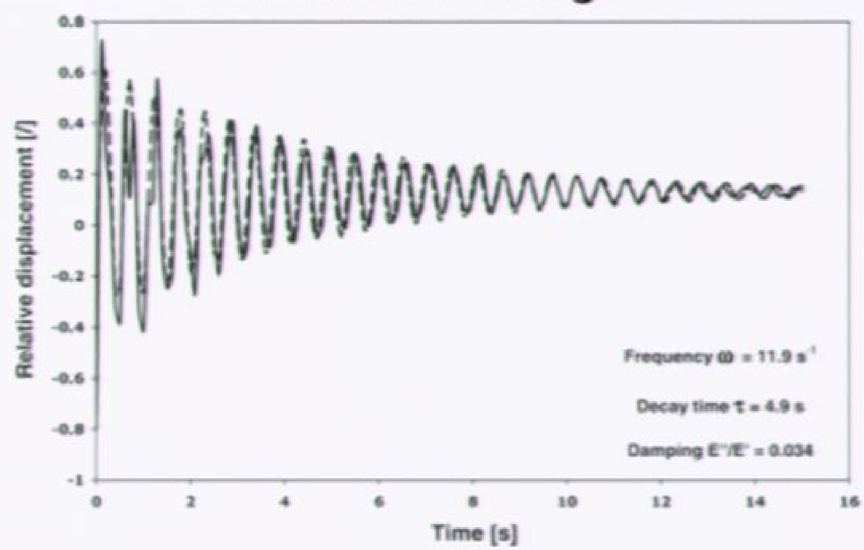

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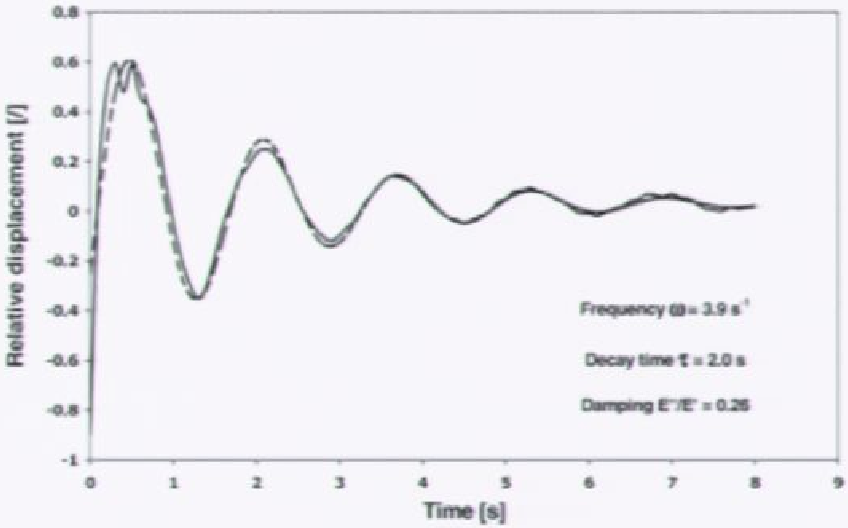

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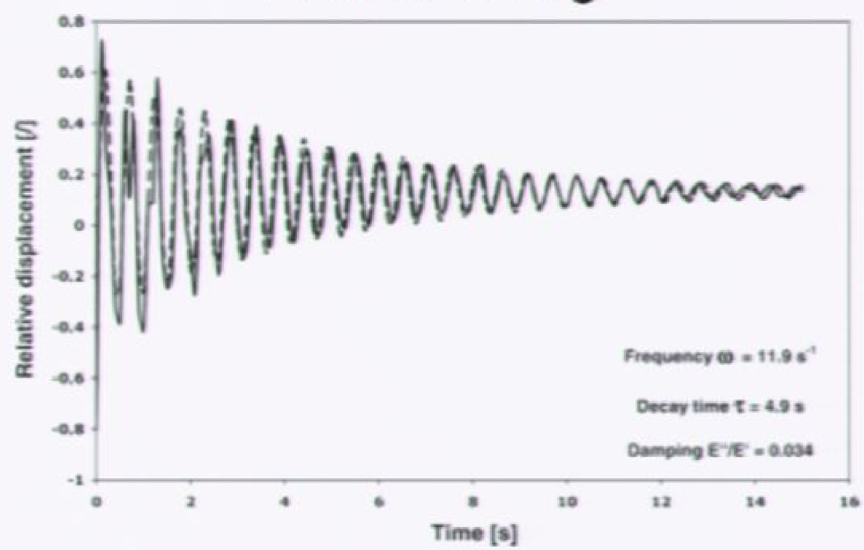

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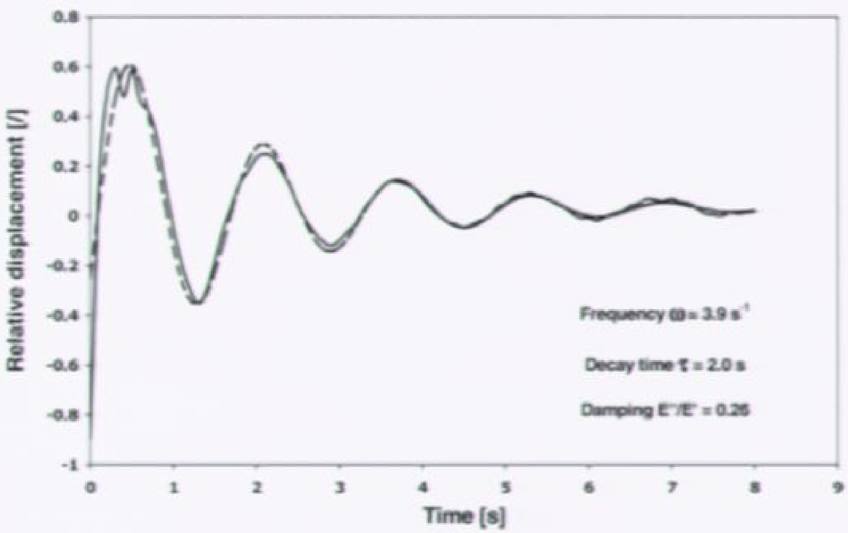

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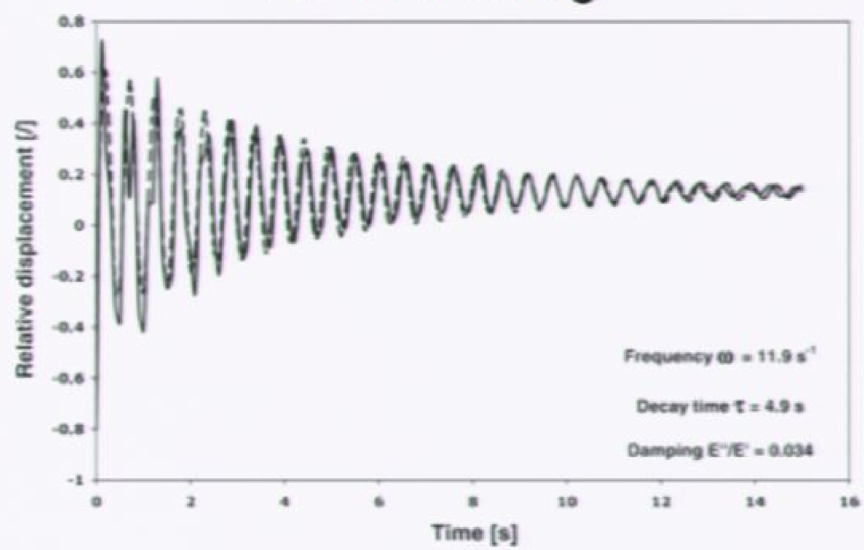

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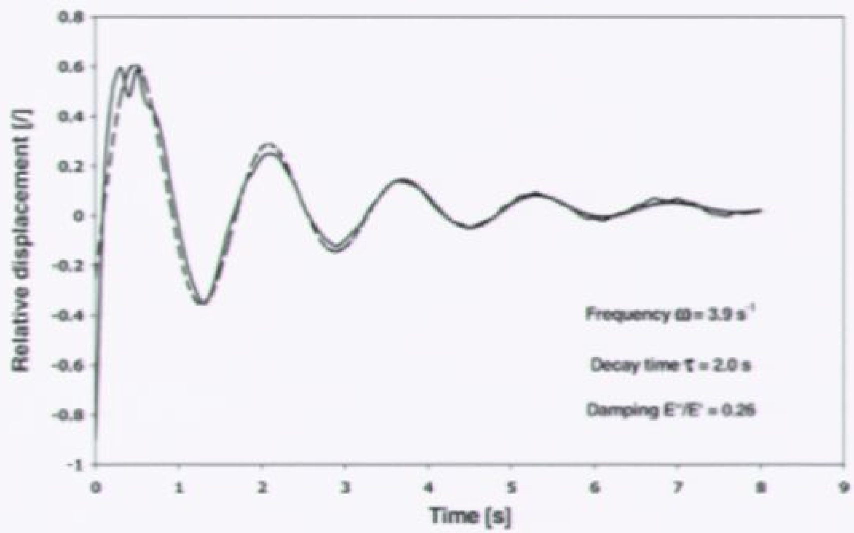

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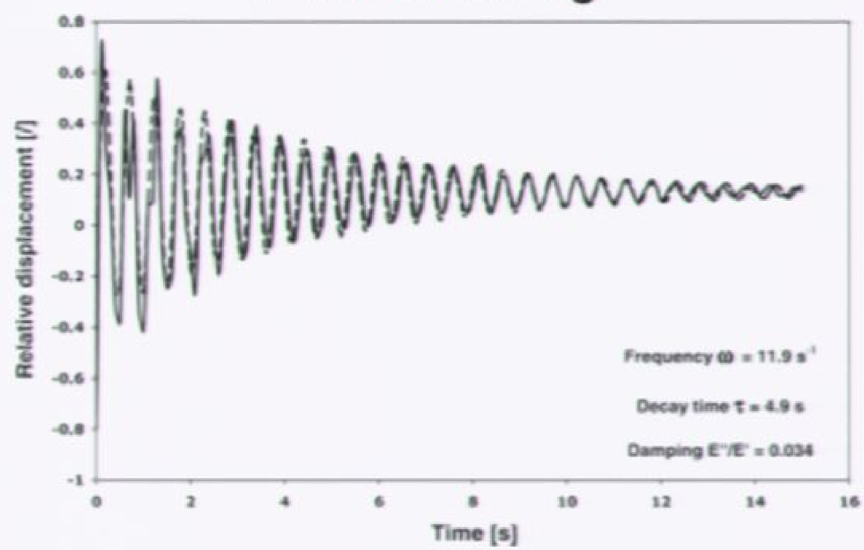

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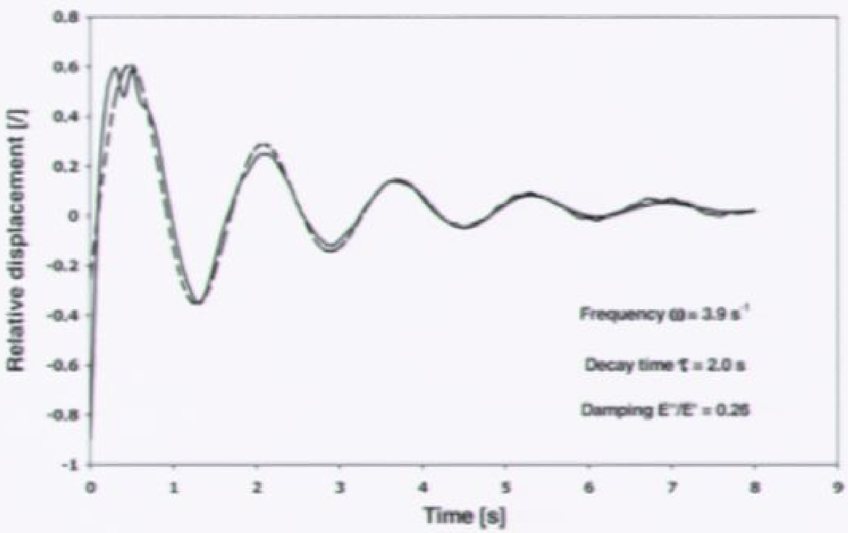

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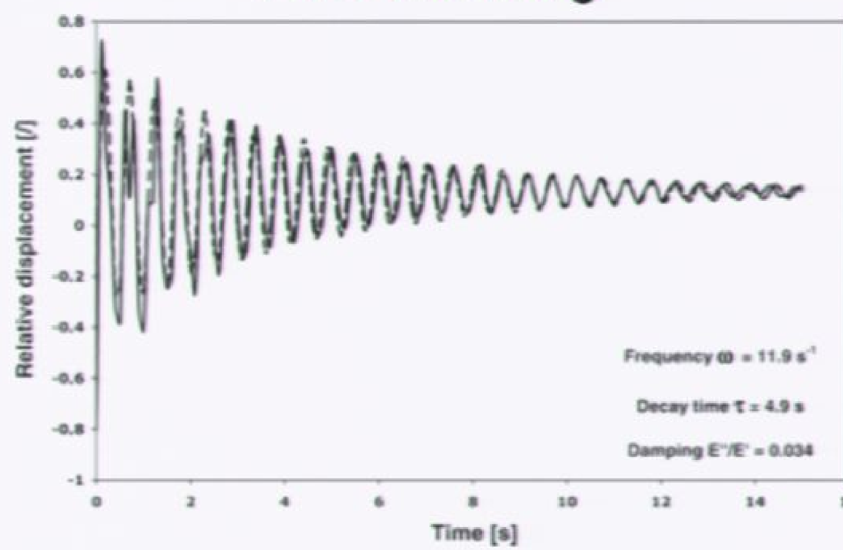

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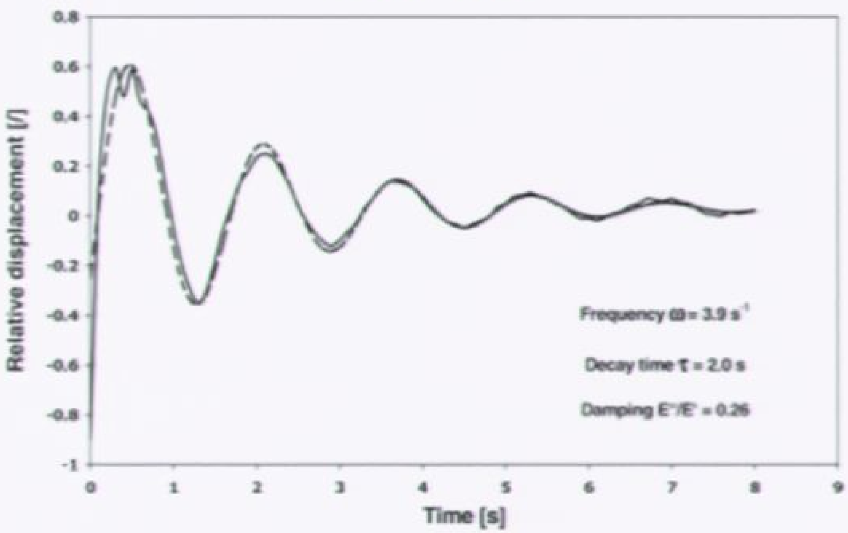

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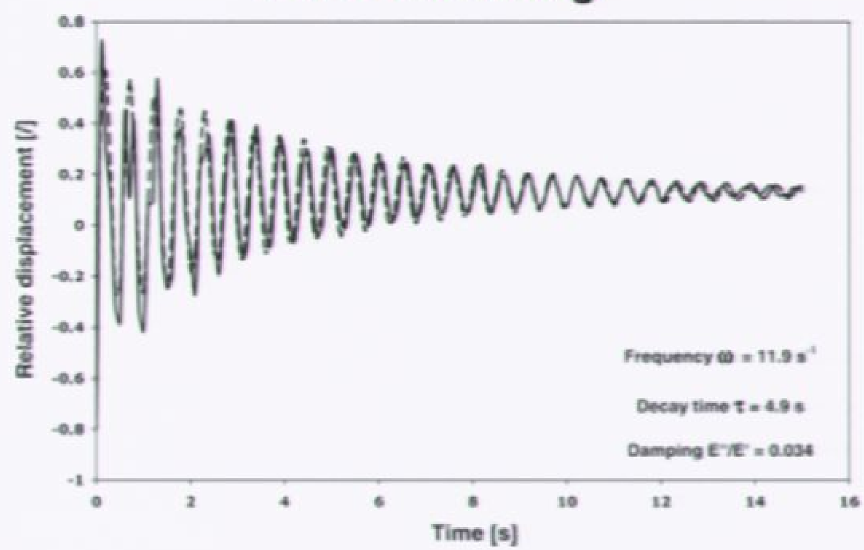

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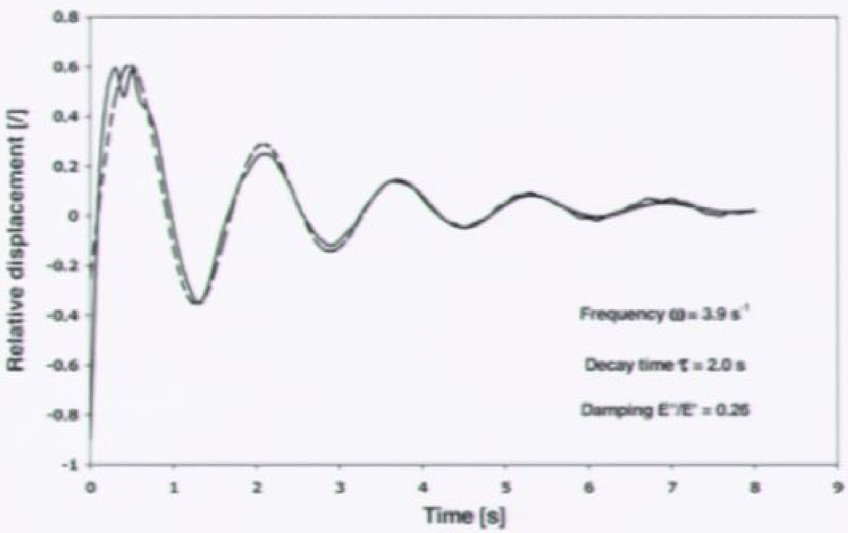

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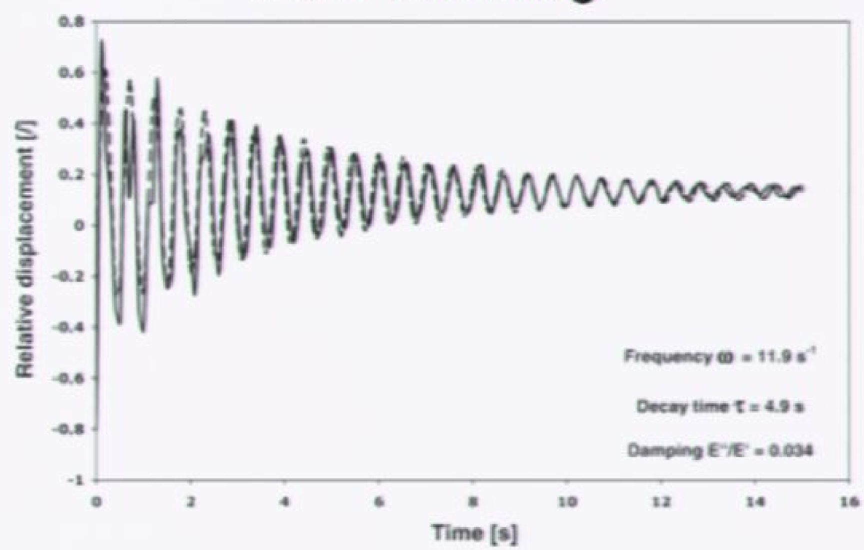

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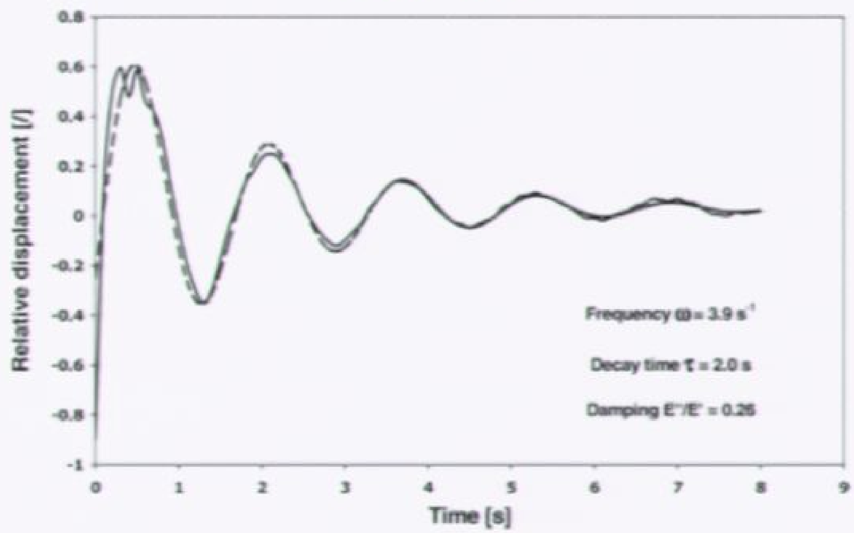

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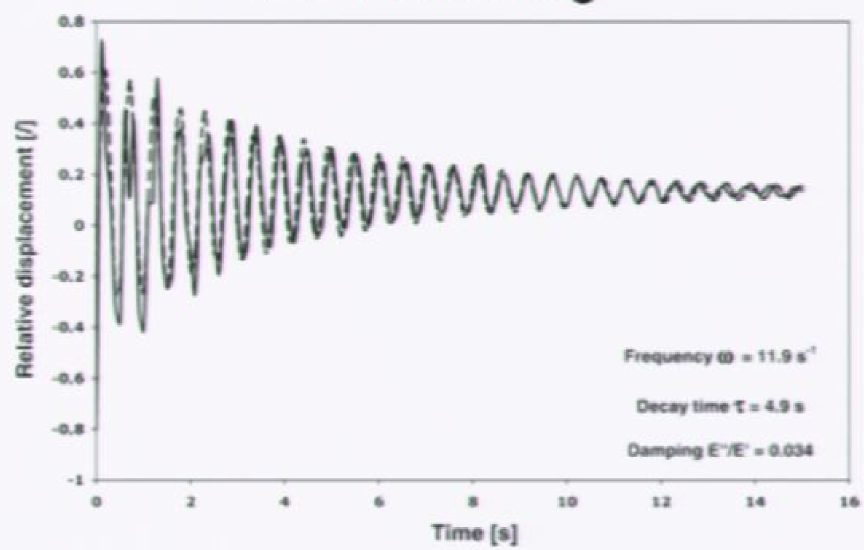

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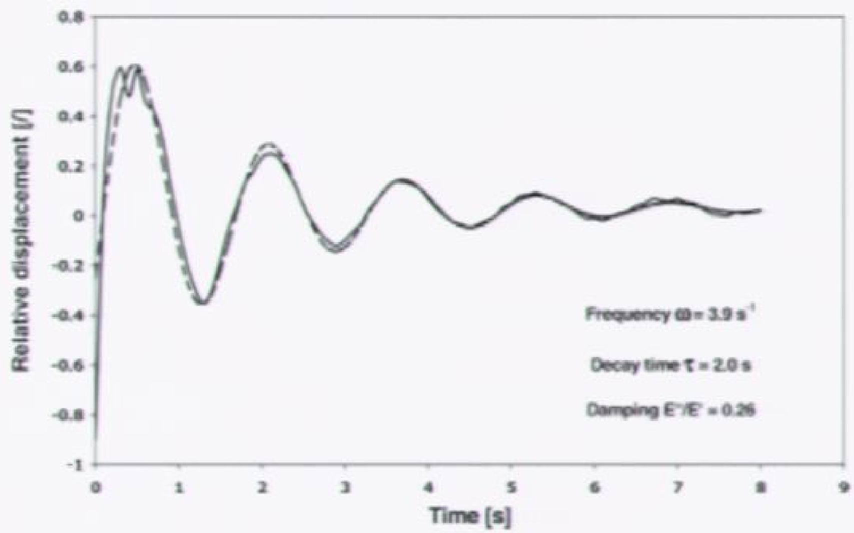

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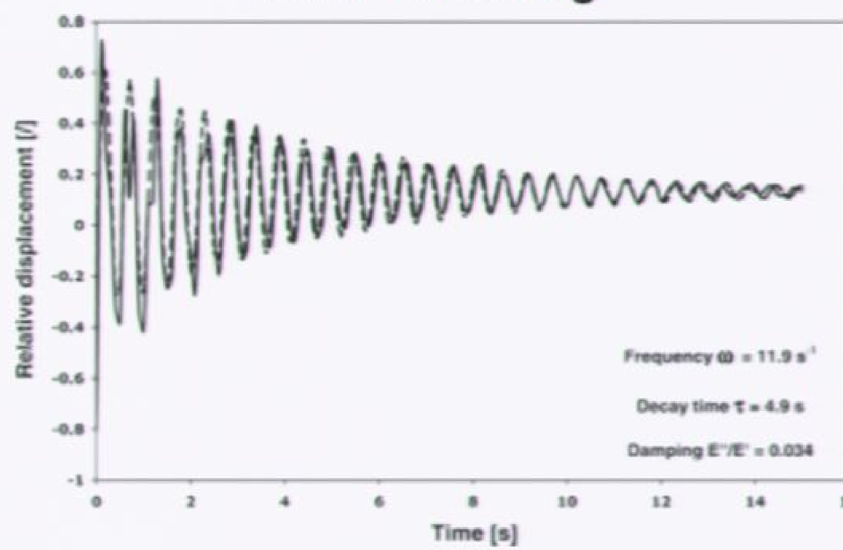

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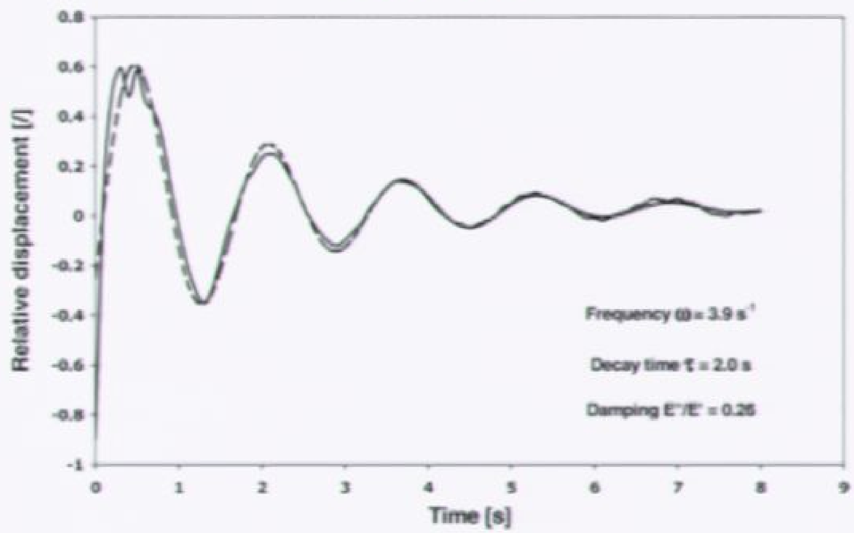

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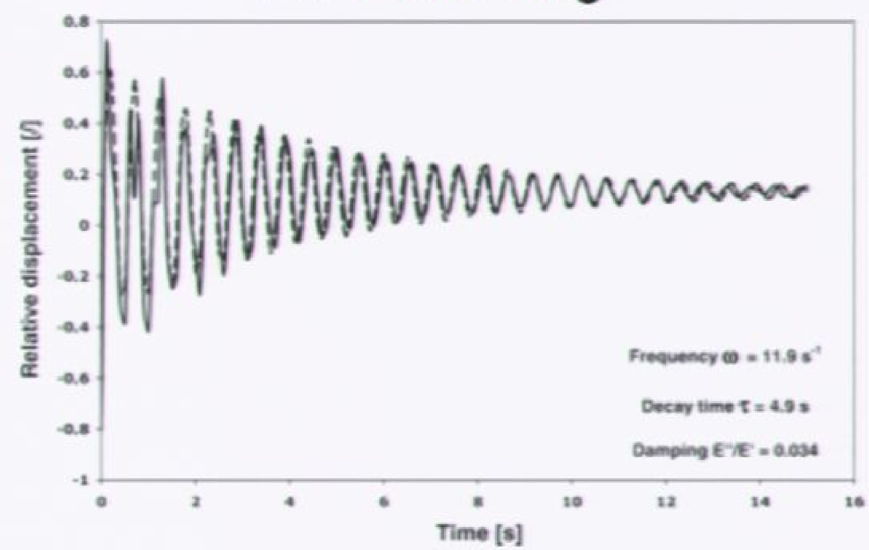

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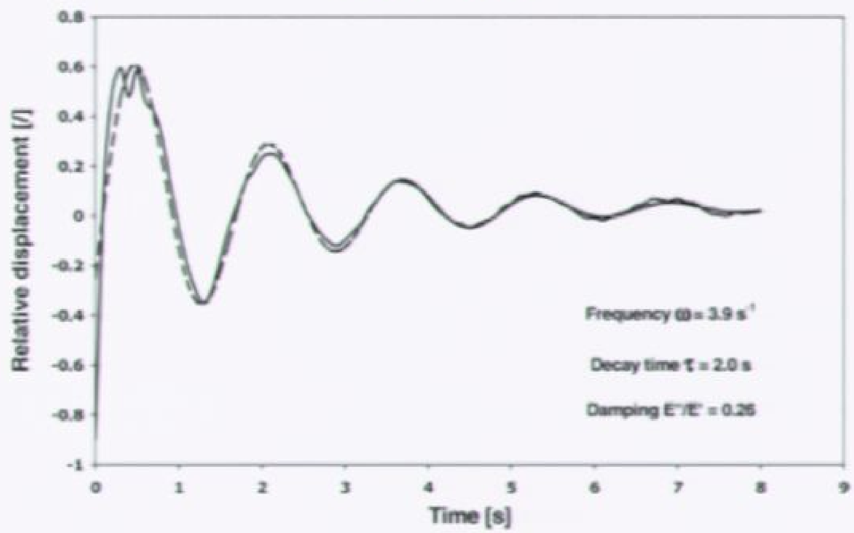

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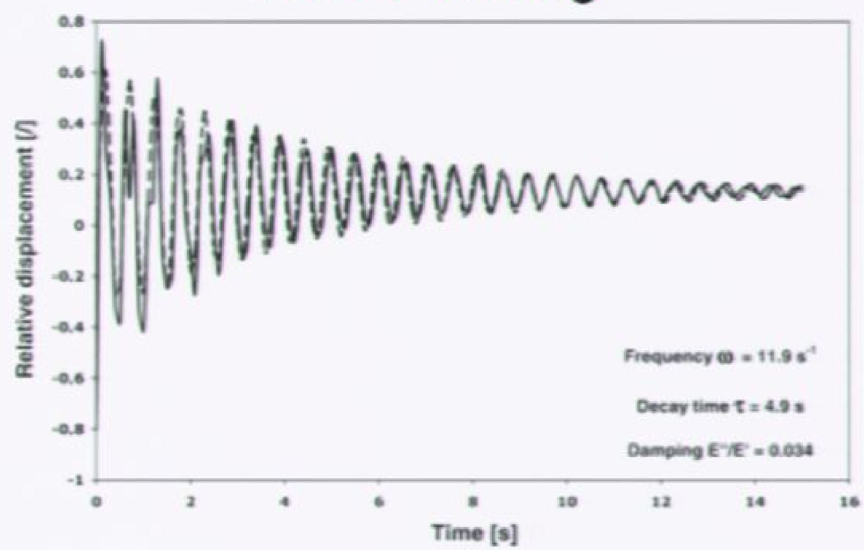

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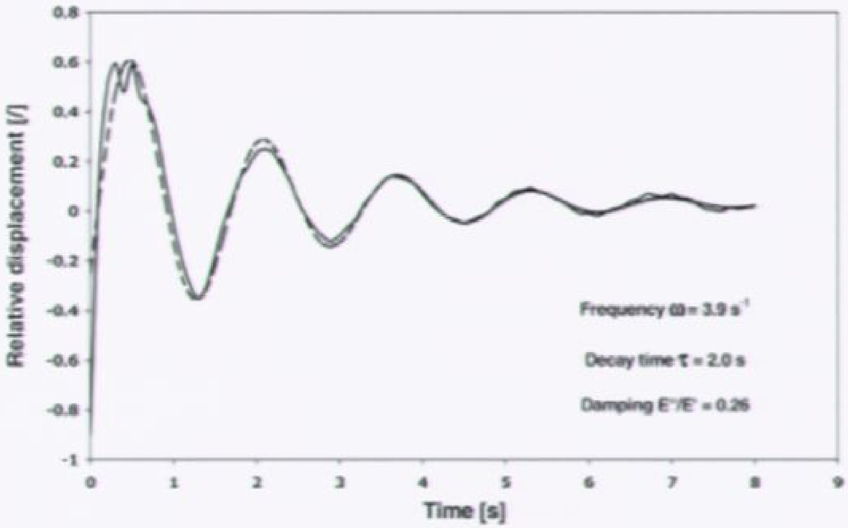

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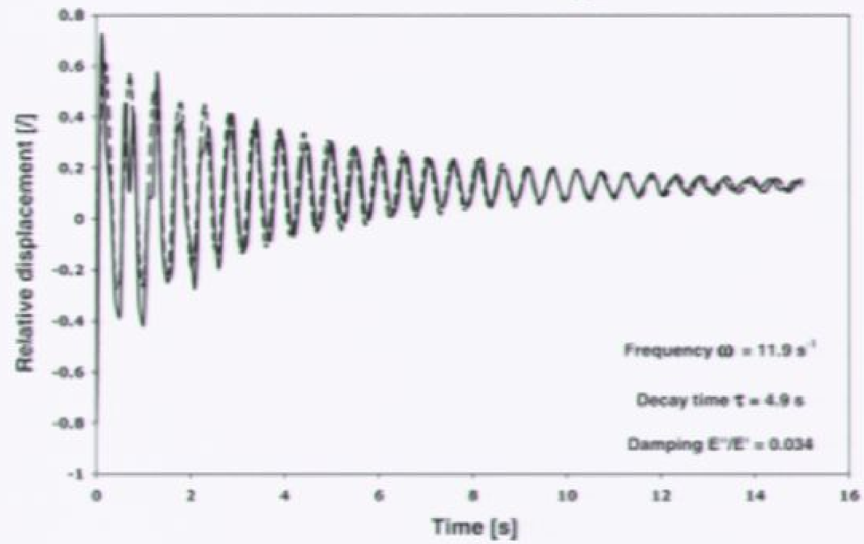

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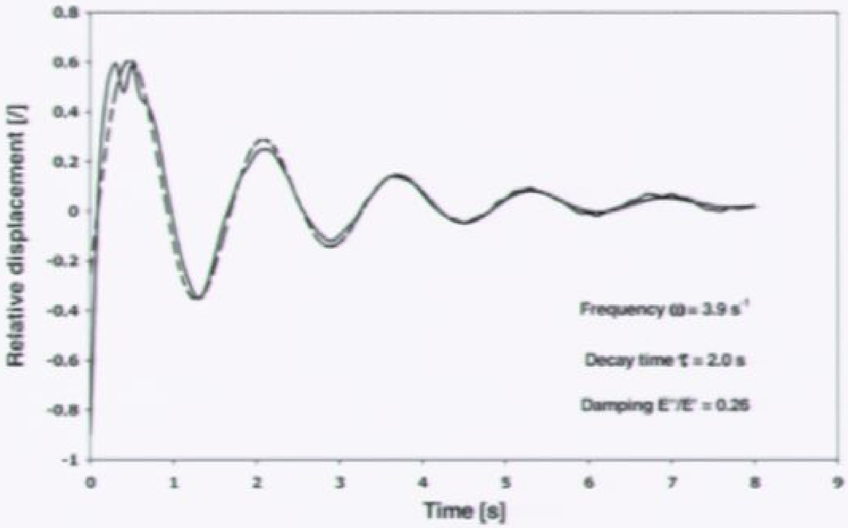

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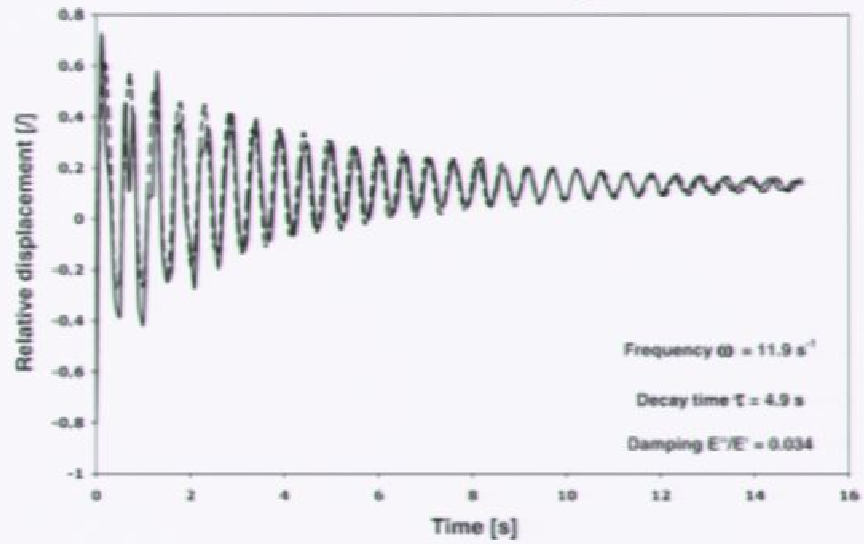

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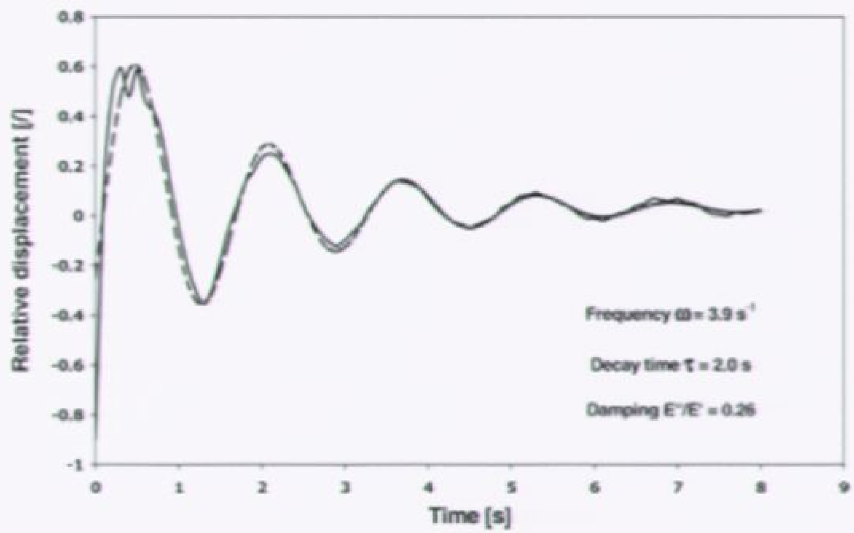

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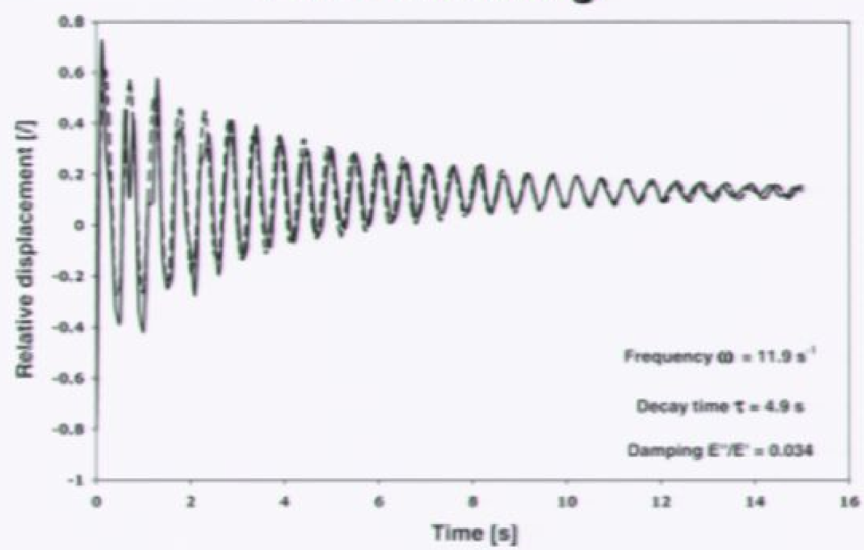

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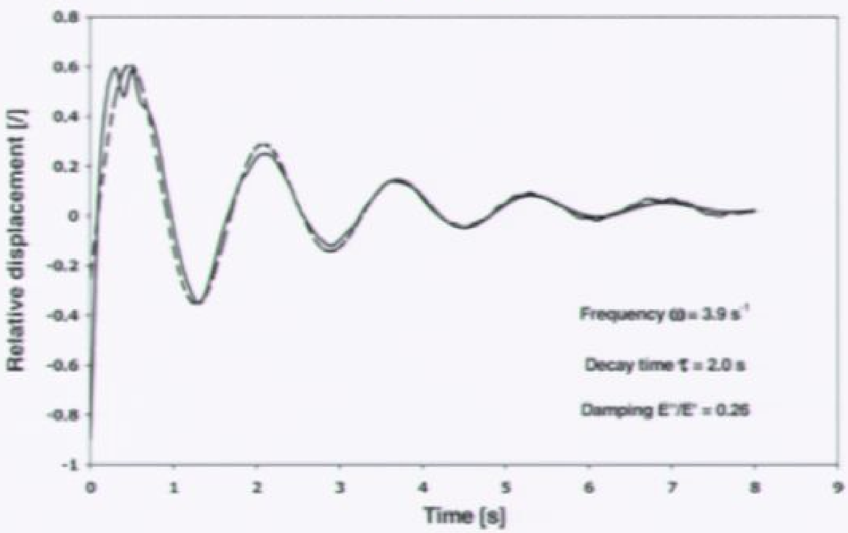

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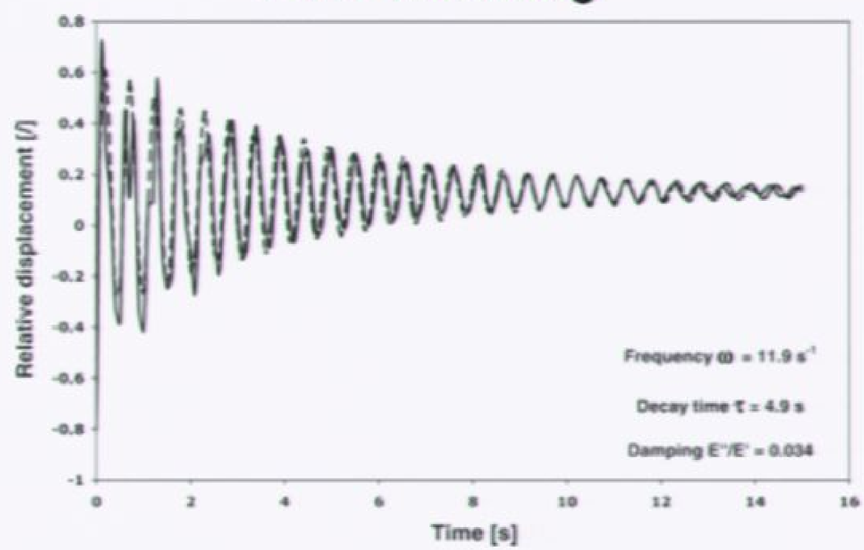

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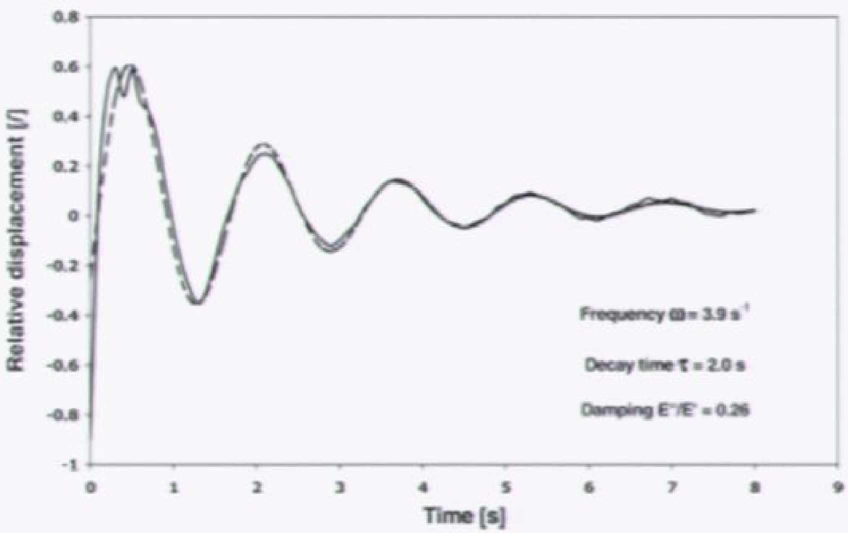

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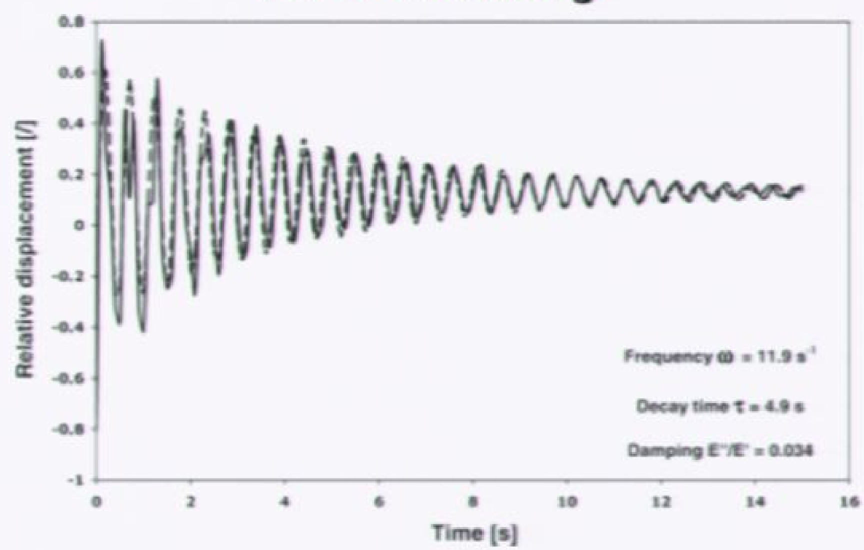

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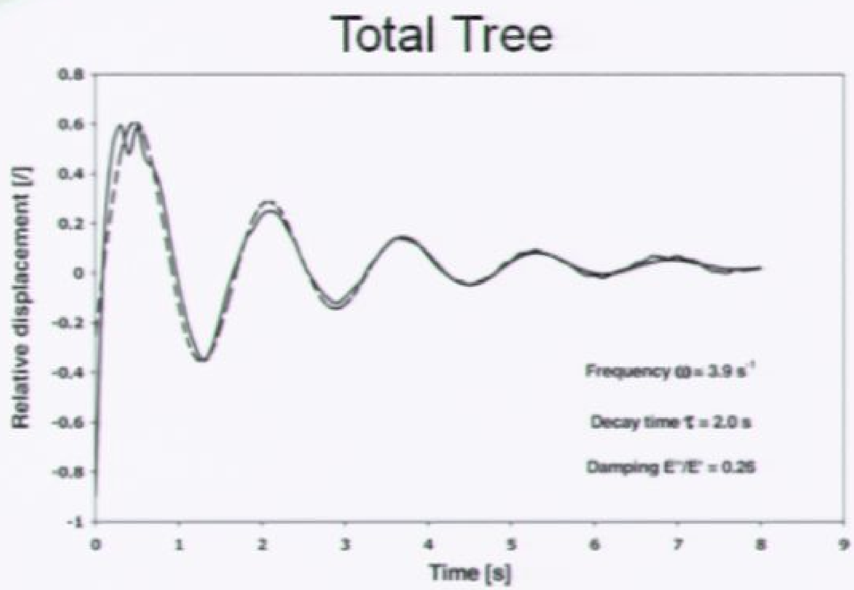

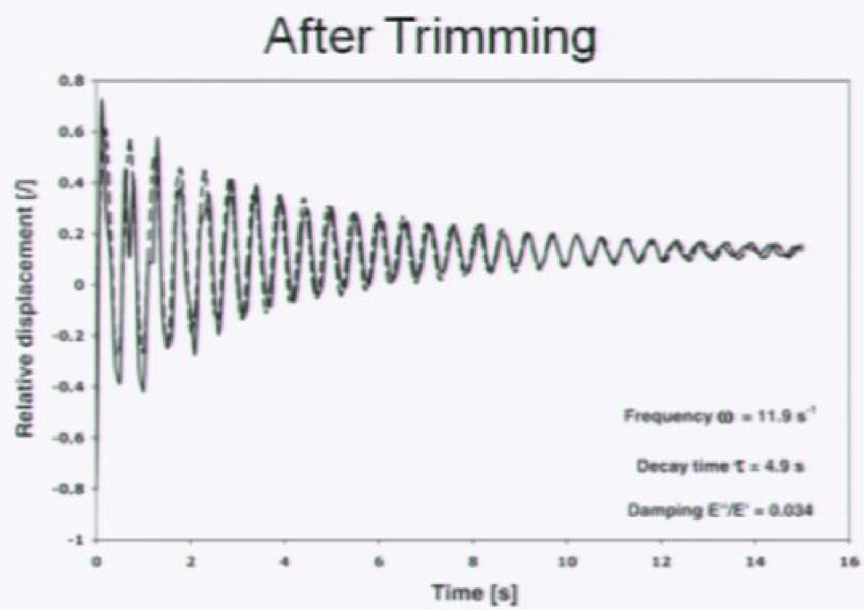

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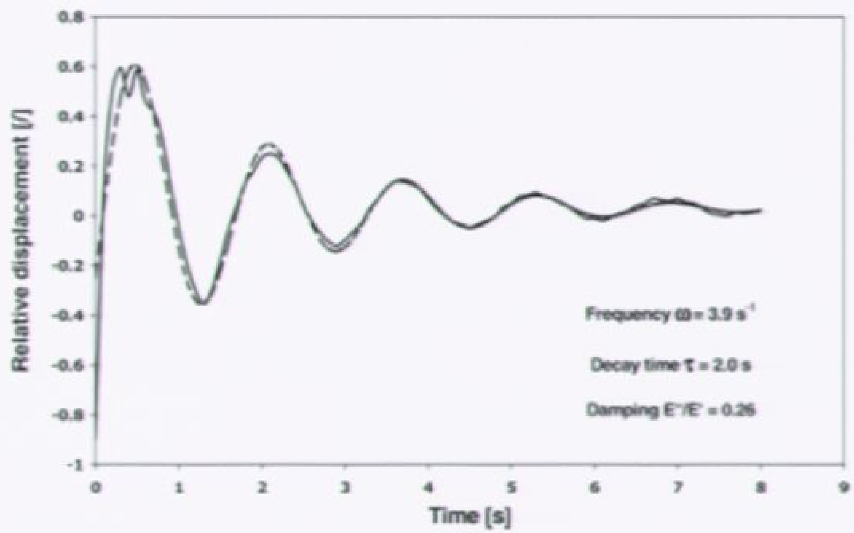
Total Tree



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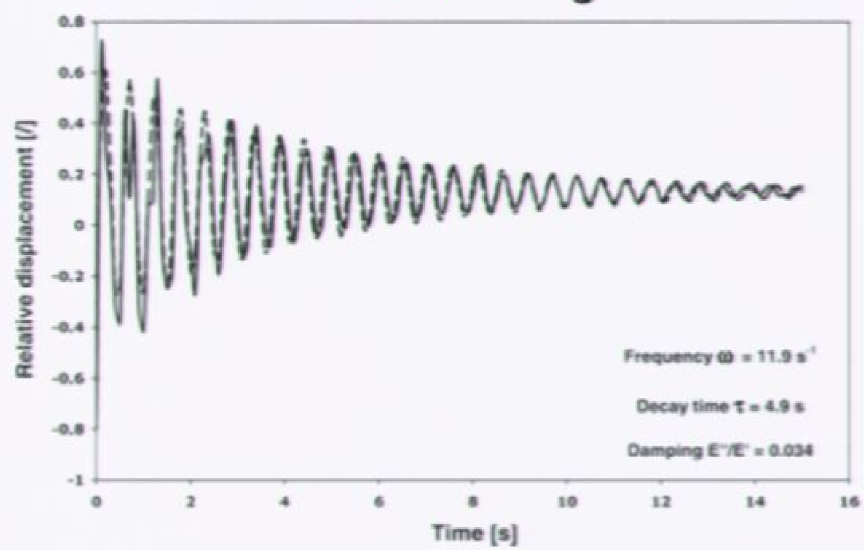

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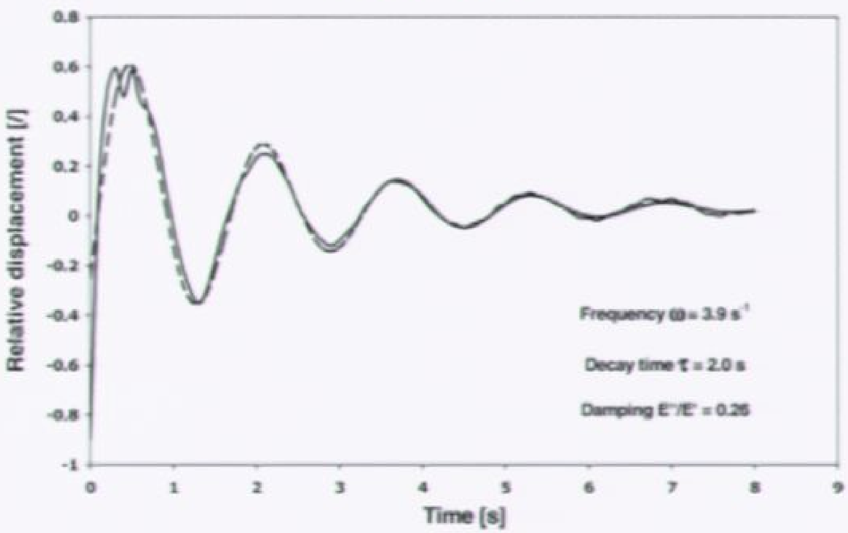

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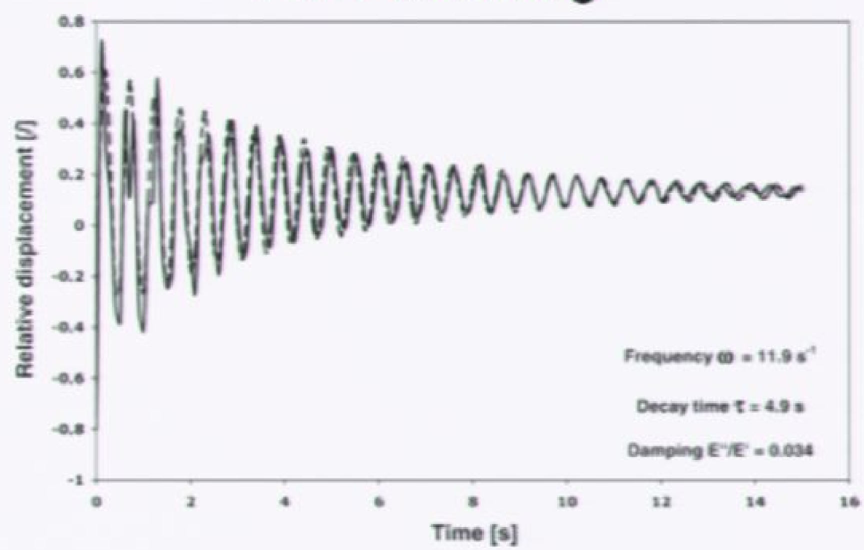

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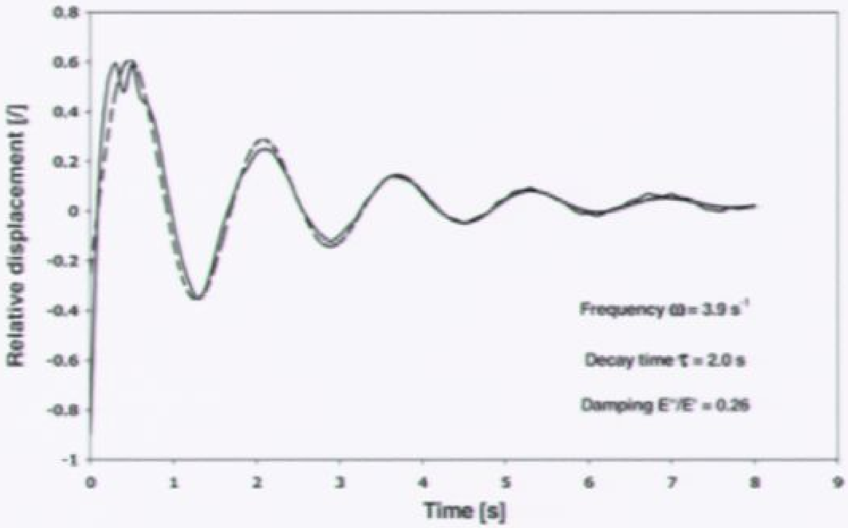

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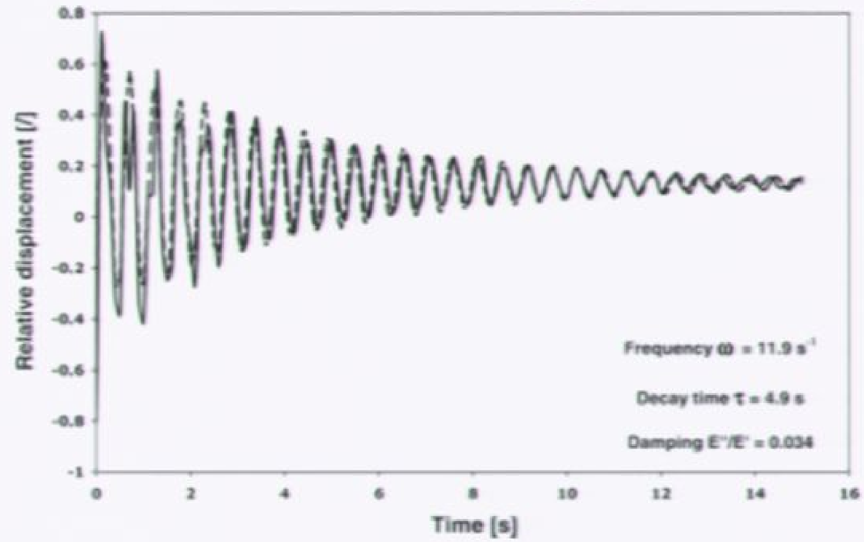

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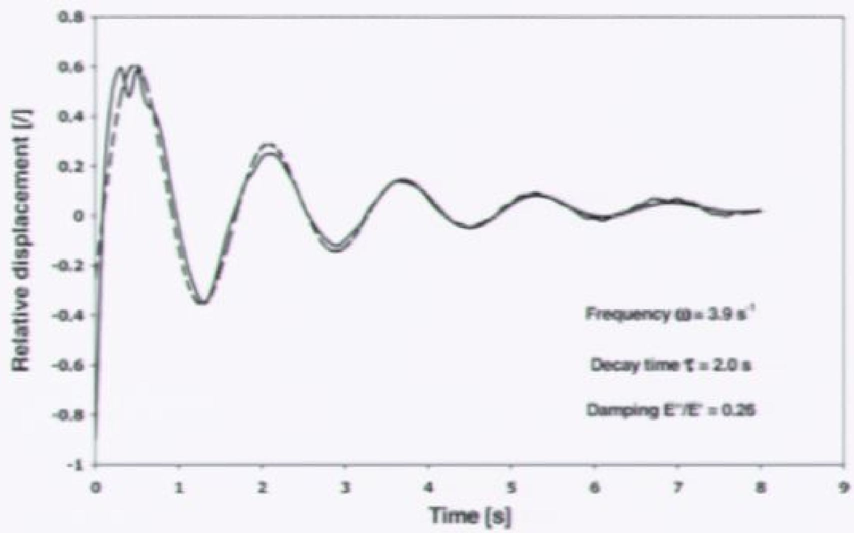

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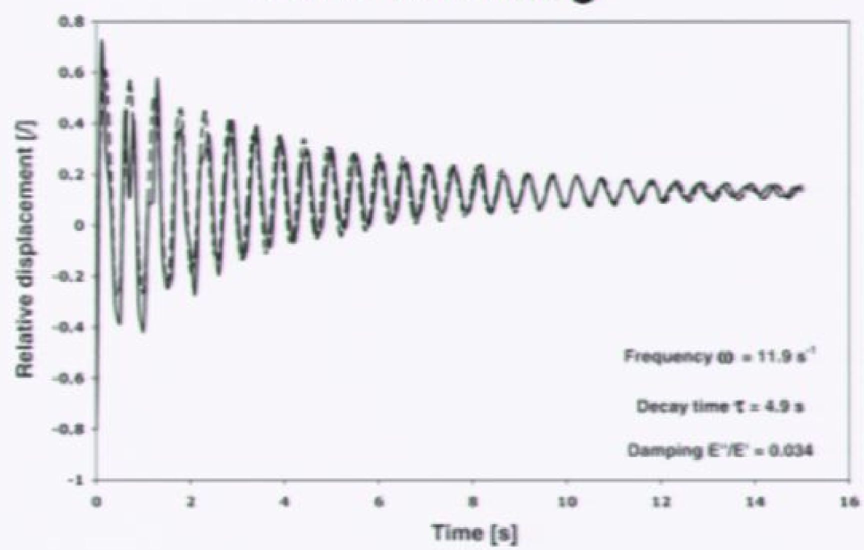

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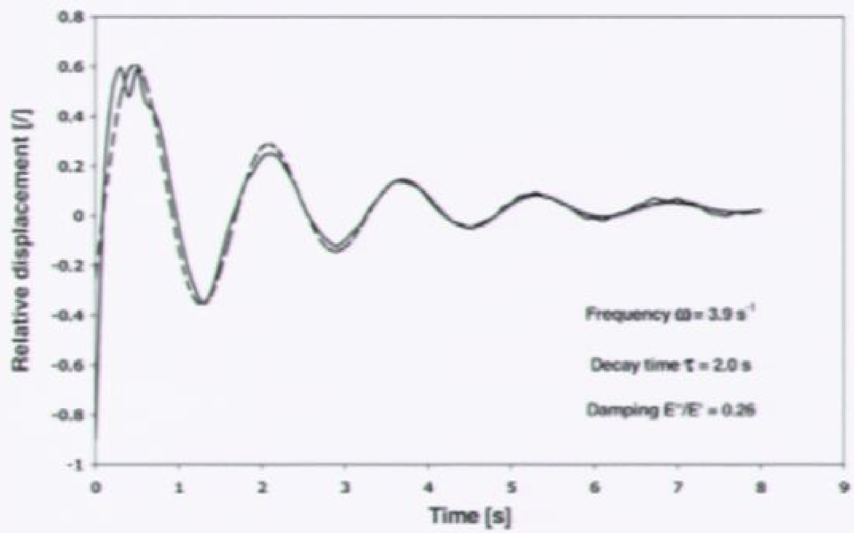

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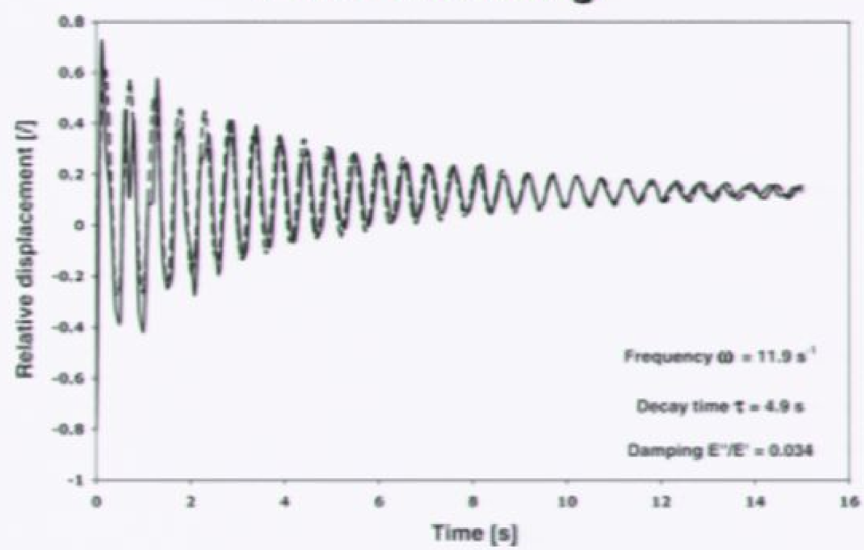

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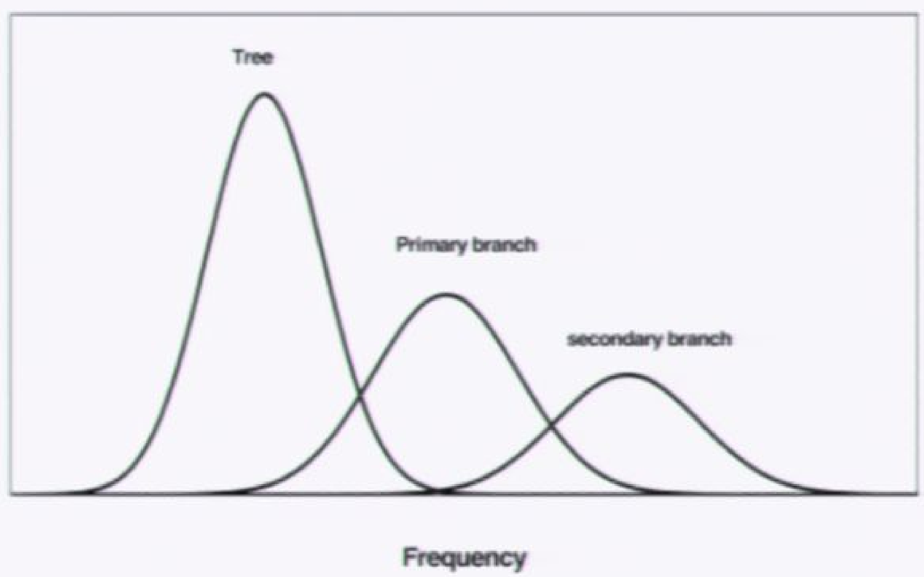

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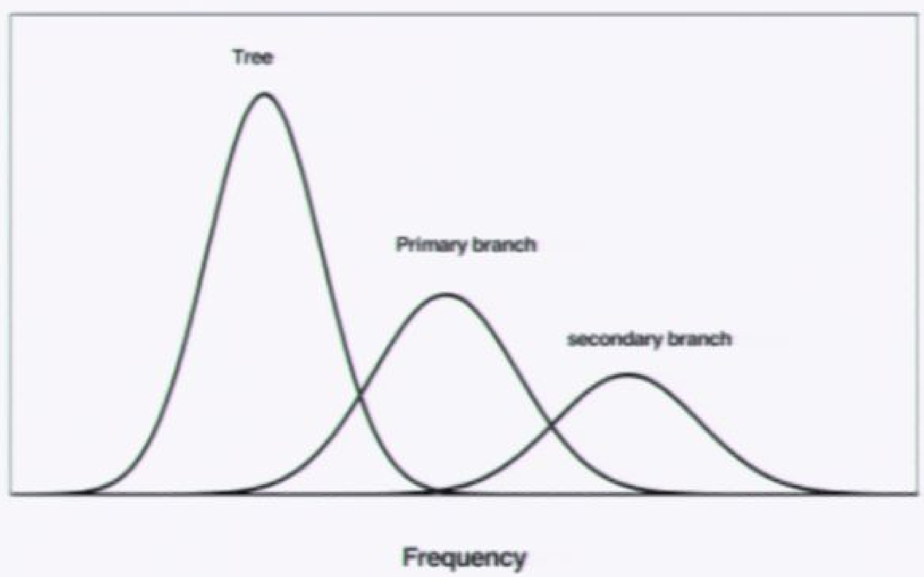

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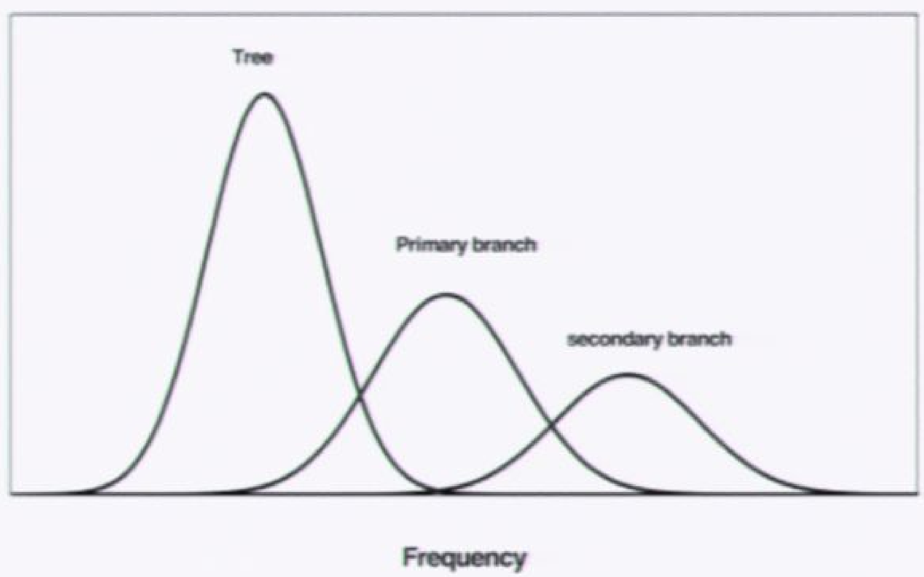

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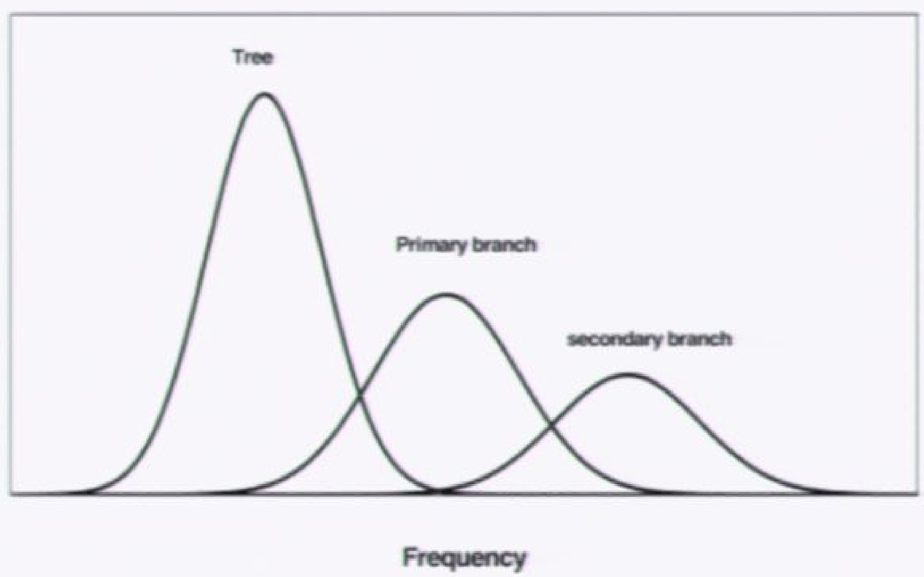

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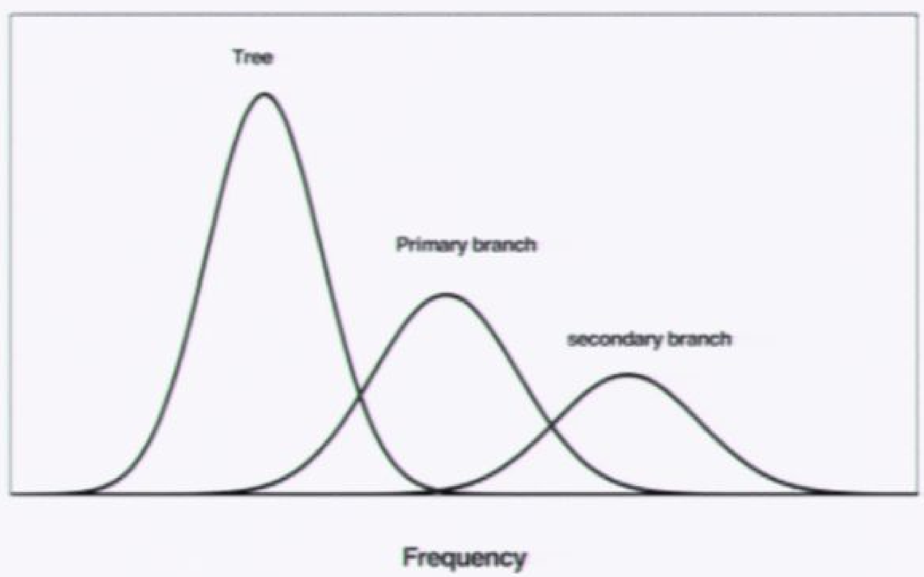

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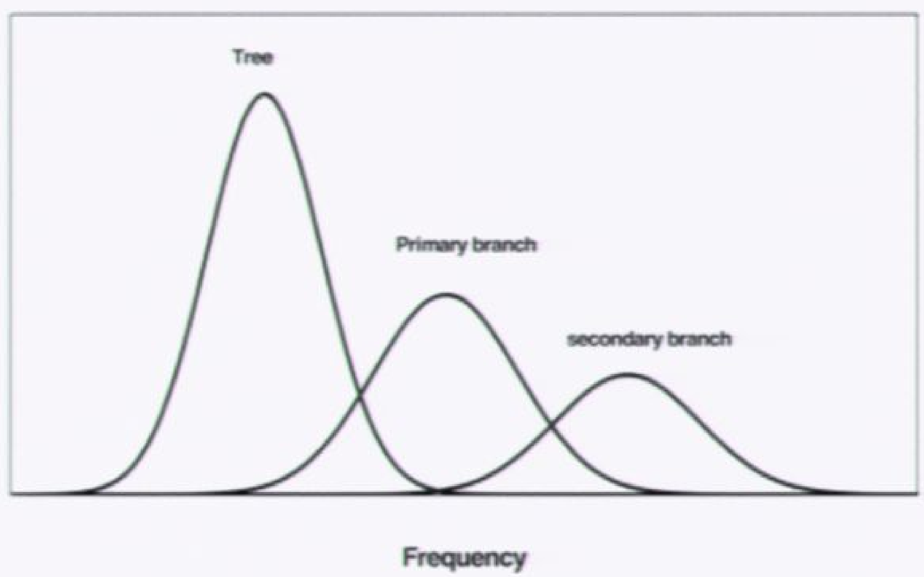

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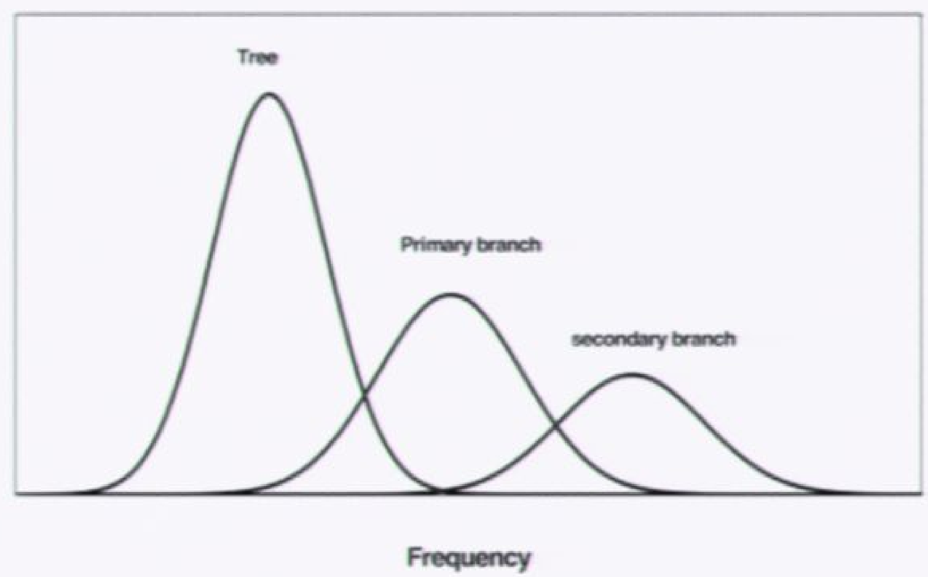

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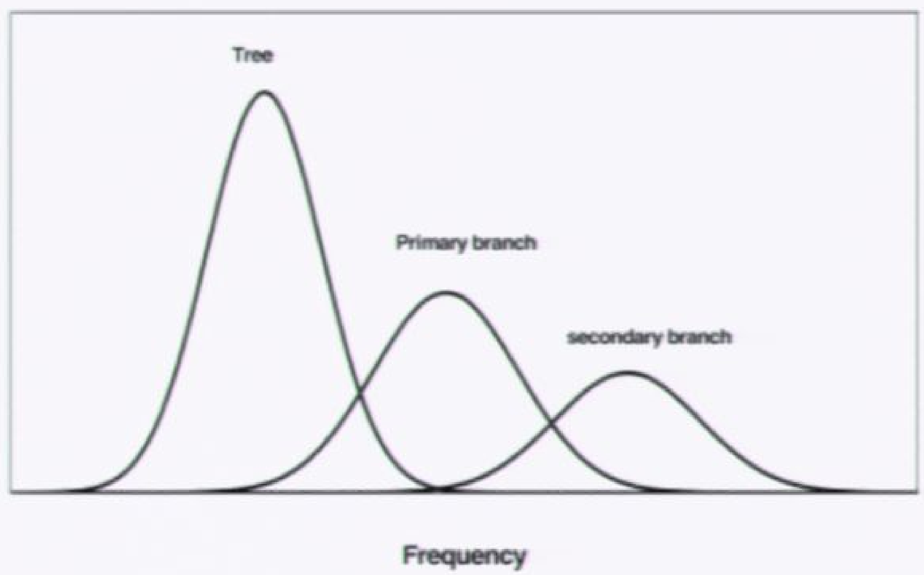

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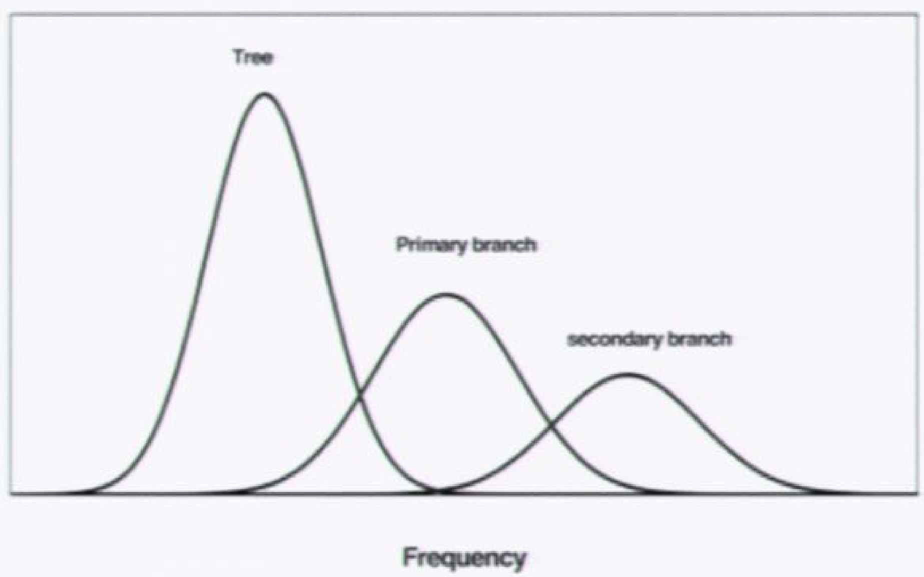

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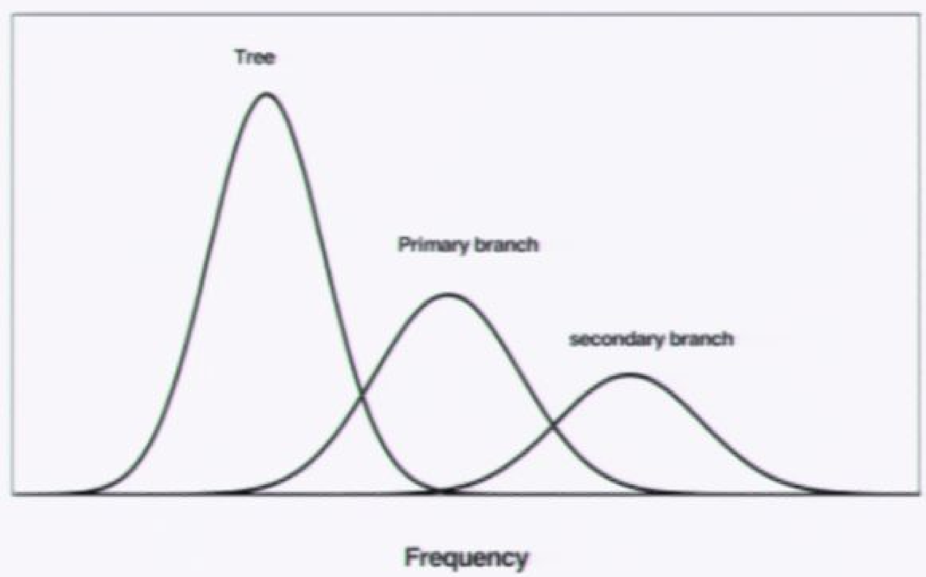

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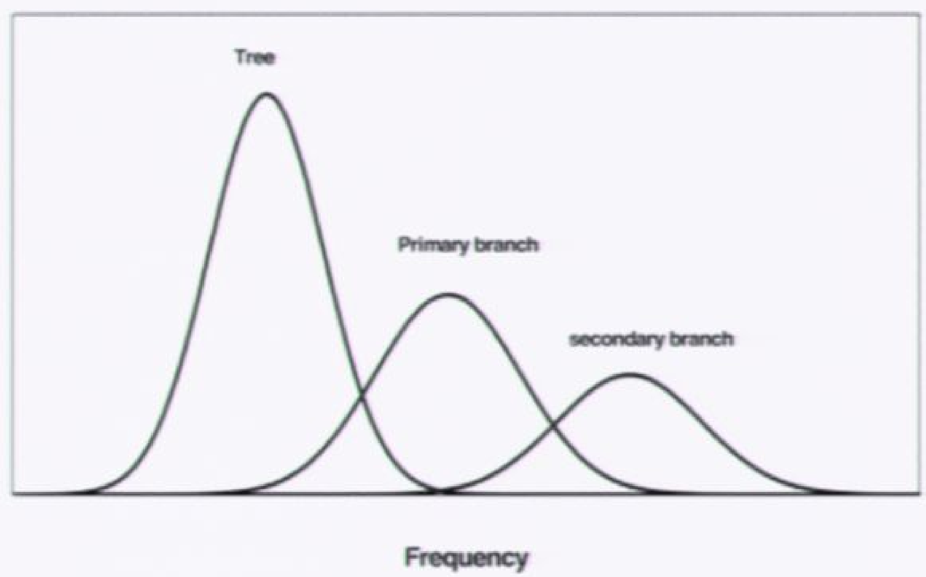

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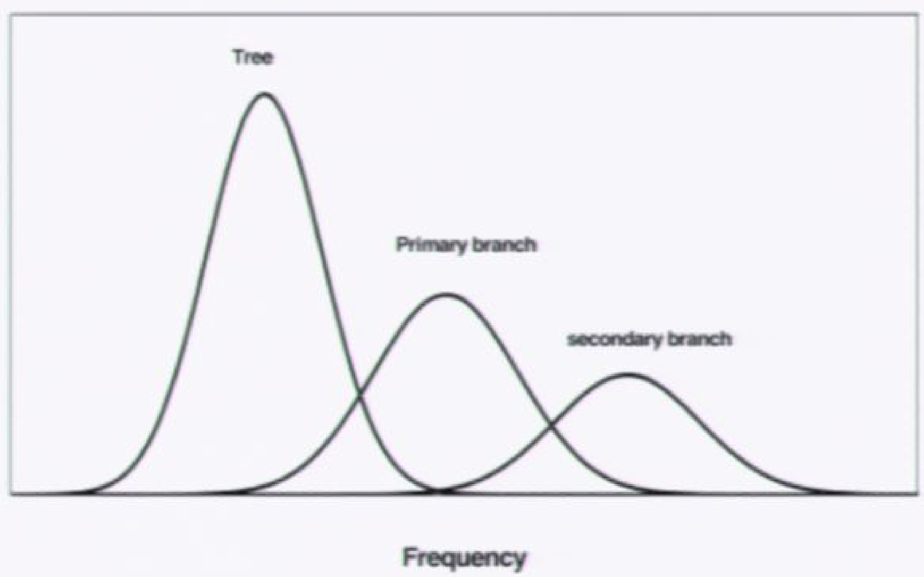

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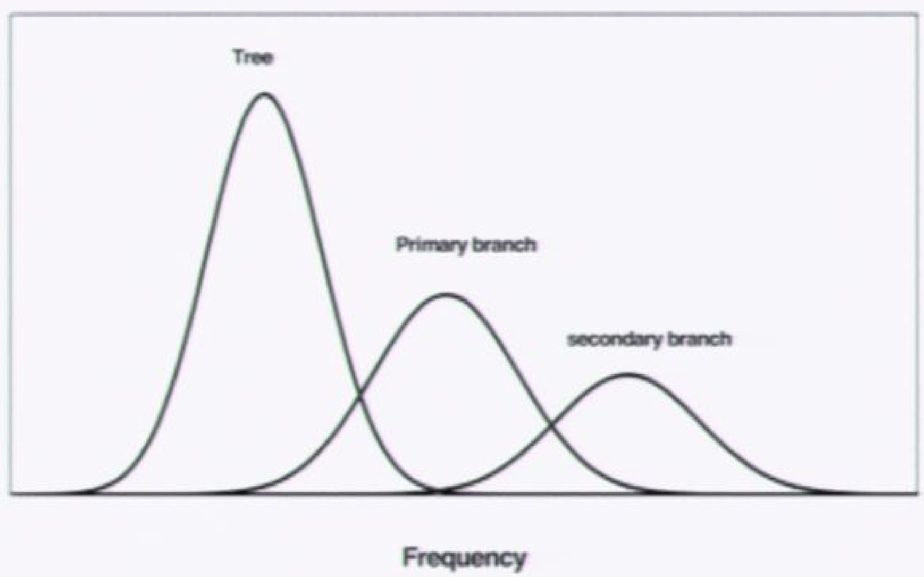

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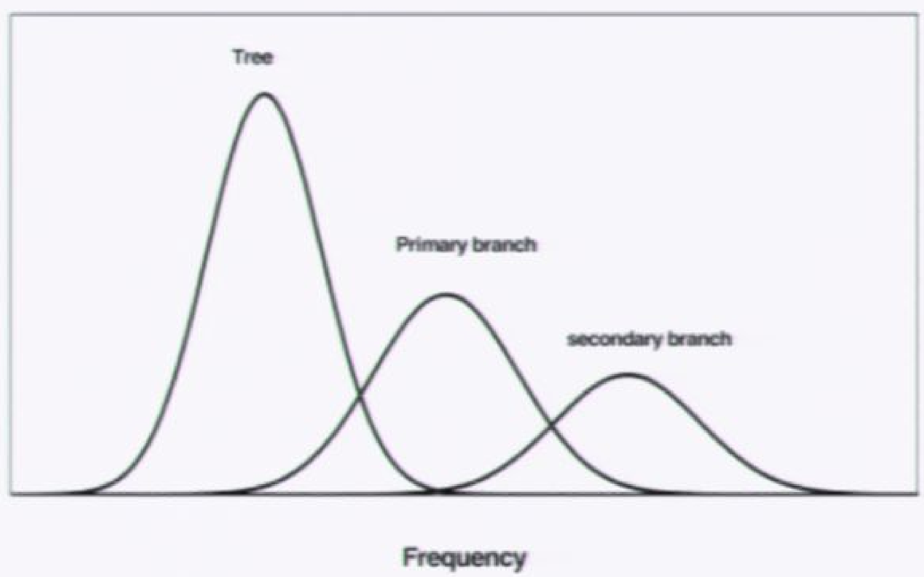

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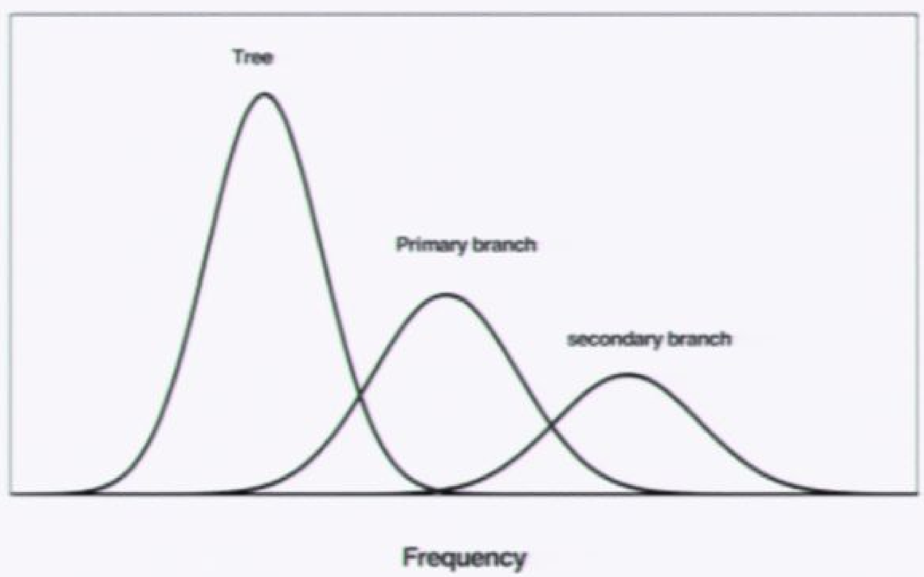

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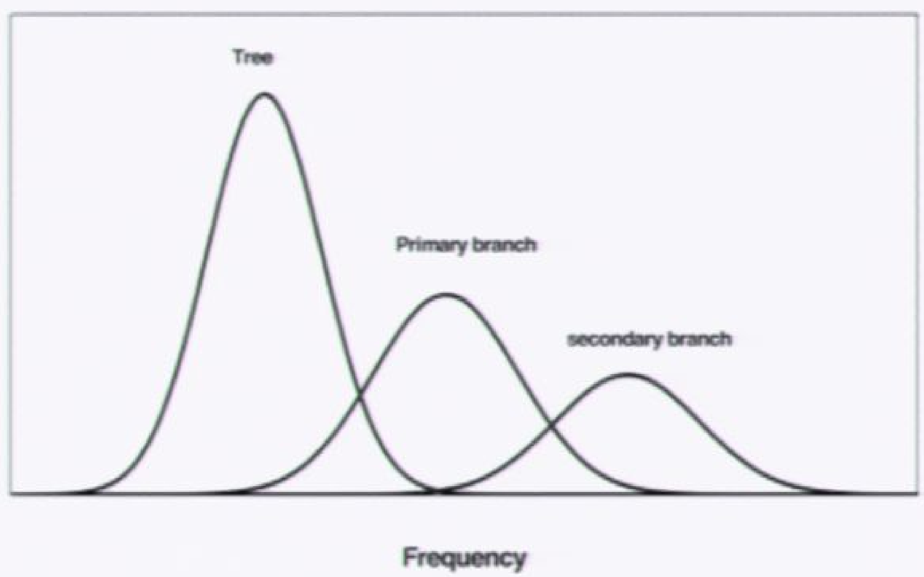

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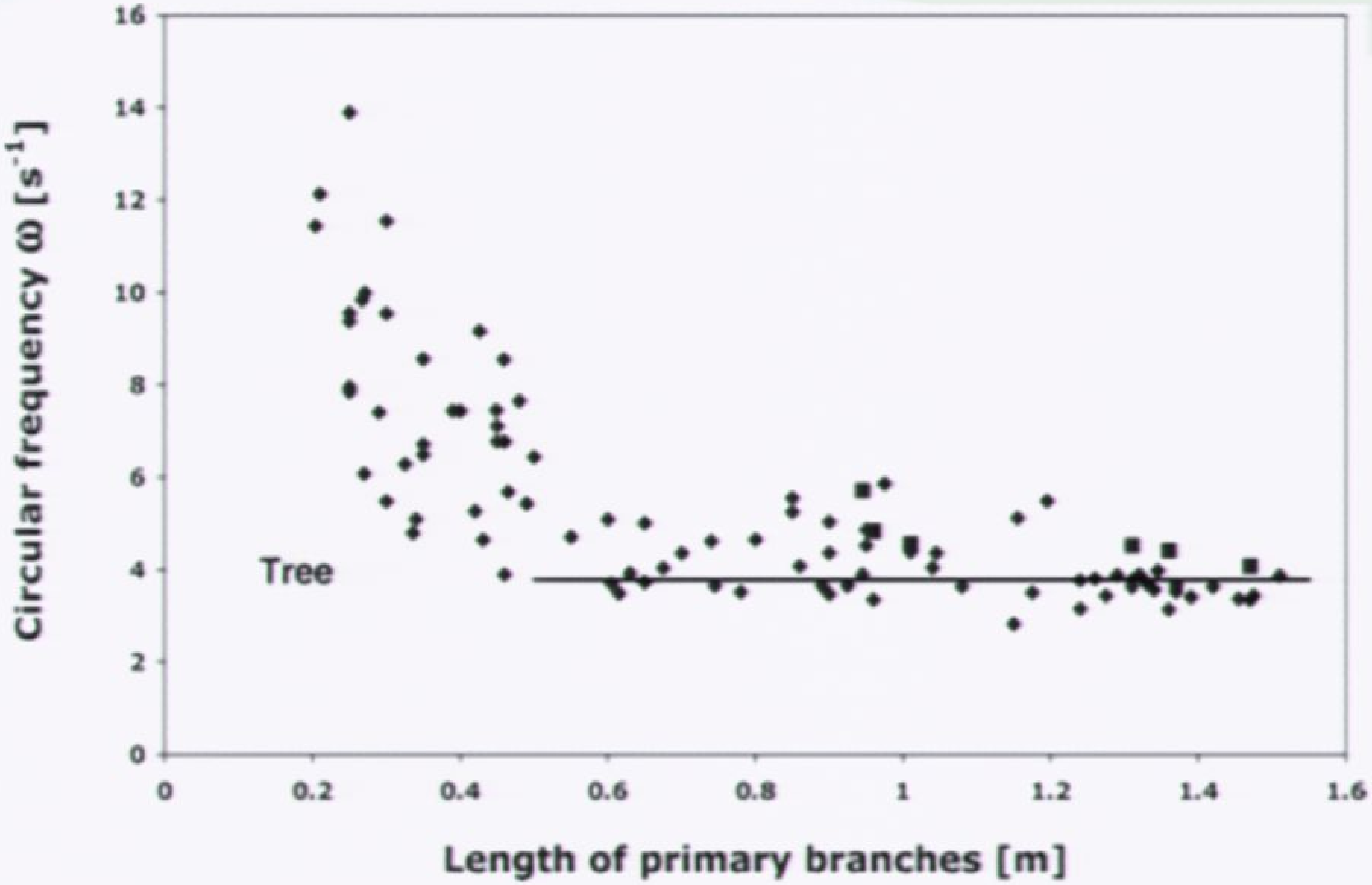
Branch Statistics



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Concluding Remarks

- Optimizes damping
- Reduces danger
- Further experiments

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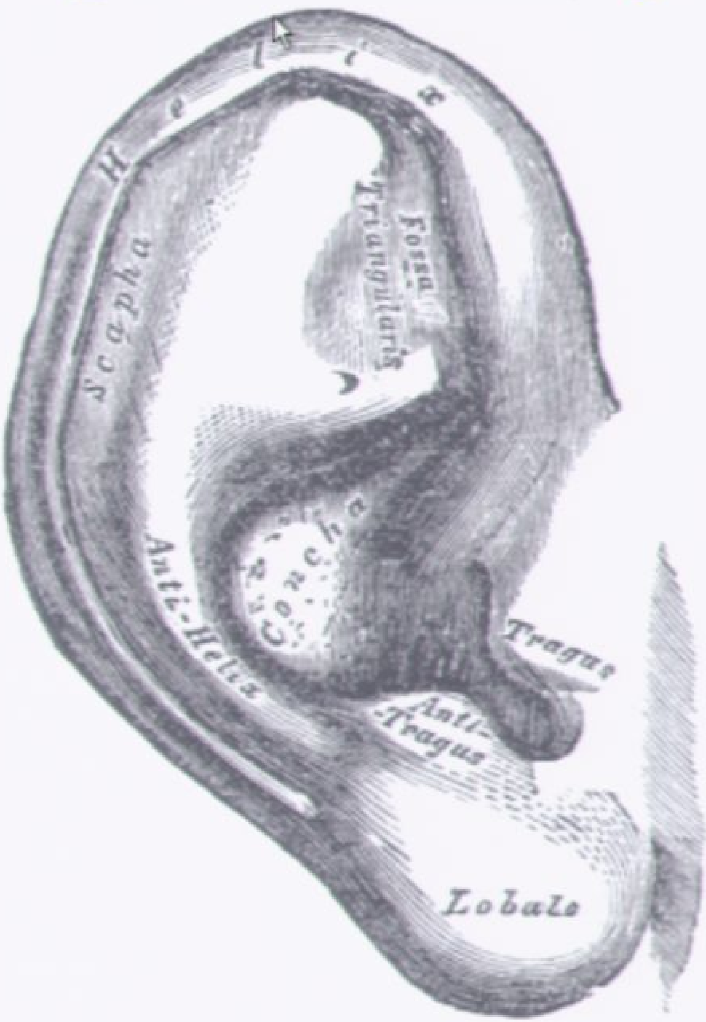
Spatial Hearing and Sound Localization



Lauren Greenspan

Perimeter Institute

Motivation

- Hearing in 3-D
- Filtering out the "noise"
- Ears favor frequencies of human speech
- Psychophysics – scientific study of perceptual system

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  - Interaural Time Difference (ITD)
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  - Wave interference

    "Spatial Hearing and Understanding Speech in Complex Environments" T. Neher, T. Behrens, D.L. Beck
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Spatial Hearing: The Psychophysics of Human Sound Localization J. Lauert

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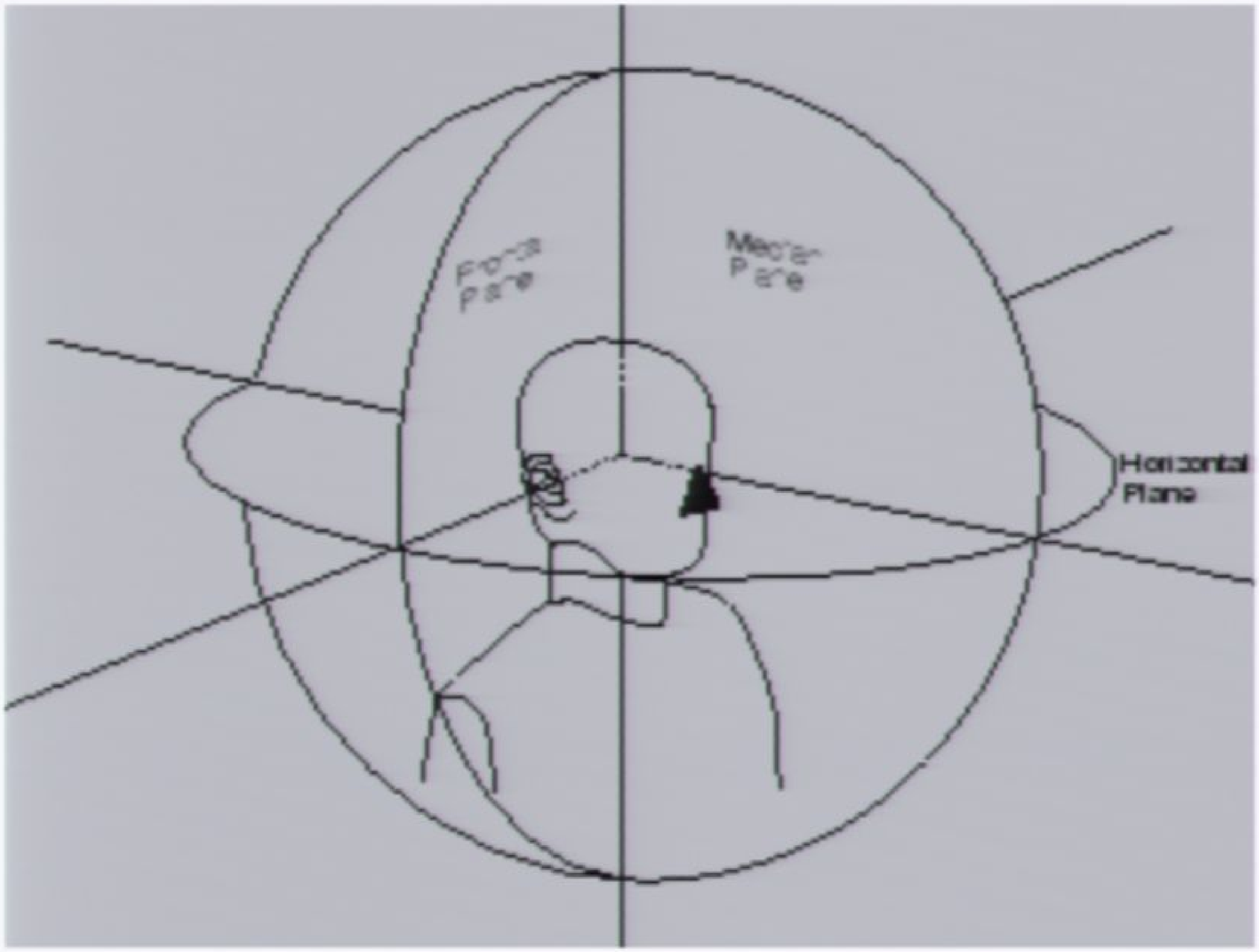
Coordinate System



www.tonmeister.ca

Interaural Time Difference (ITD)

- Phase difference between the ears causes time delay
- Helps localize sound's origin
- Most useful for frequencies below 1500 Hz

www.diracdelta.co.uk

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Interaural Level Difference (ILD)

- Negligible for frequencies below 1000 Hz
- Sound intensity "shadowed" by head

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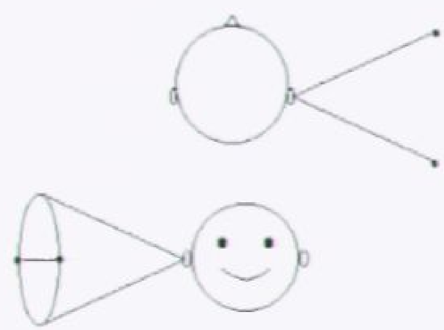
- Cone of confusion
  - Resolved by head movements for pure tones



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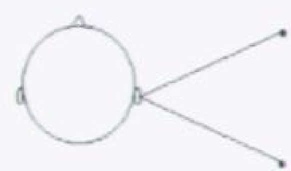

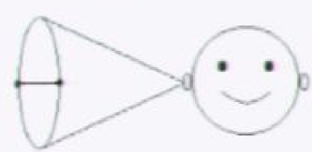

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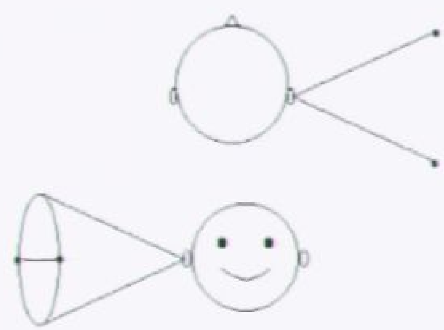

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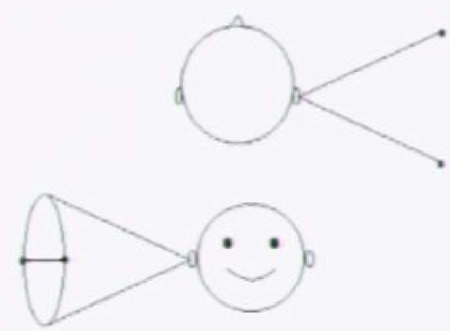

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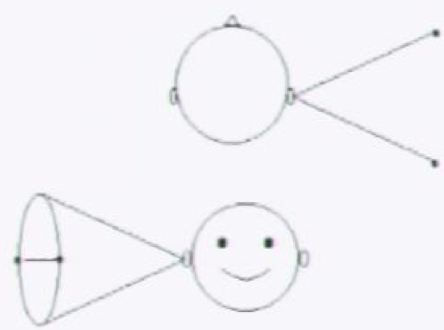

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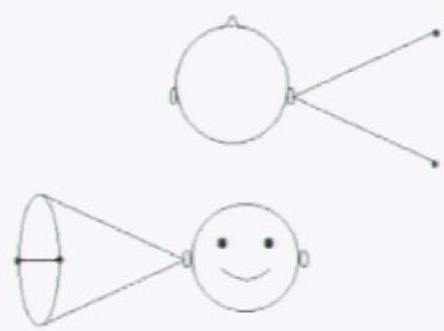

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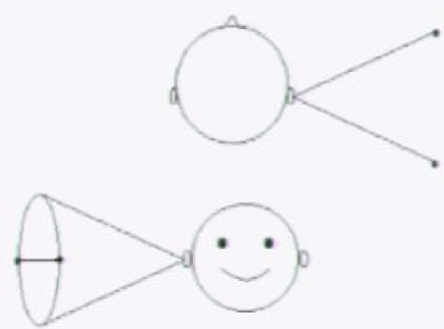

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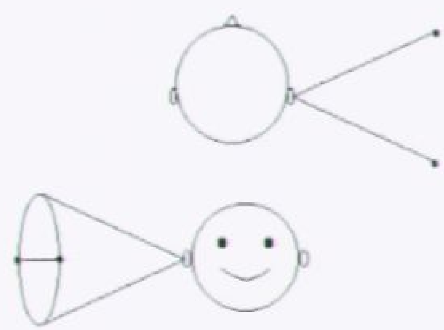

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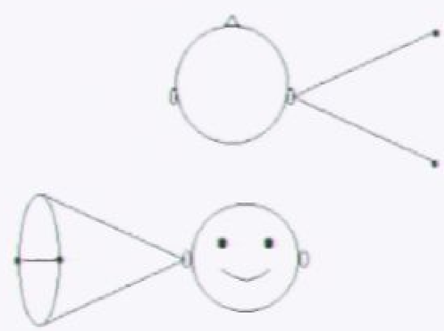

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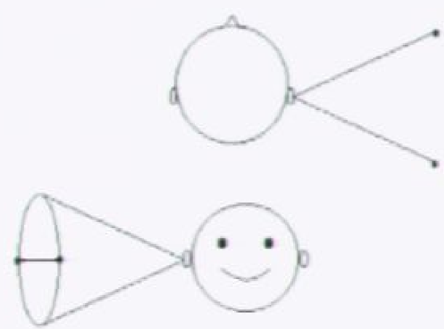

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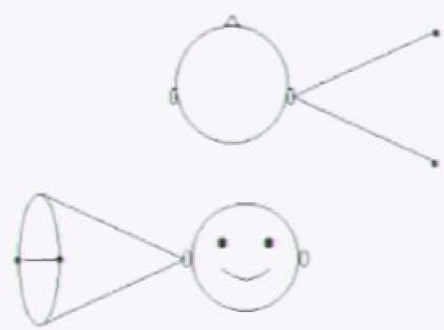

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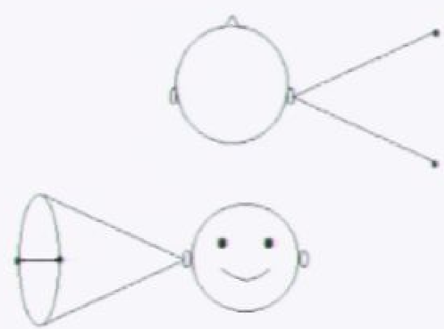

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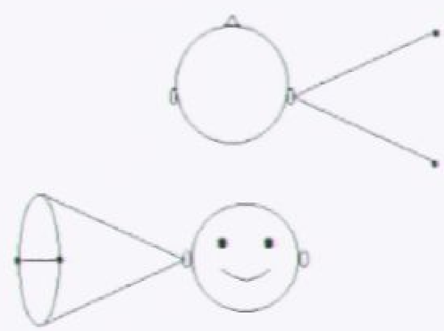

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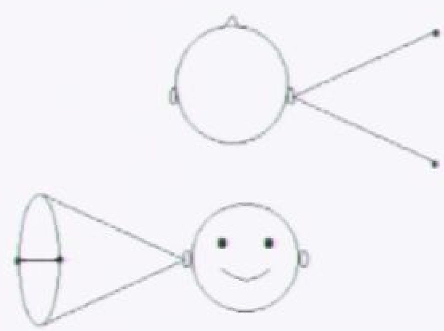

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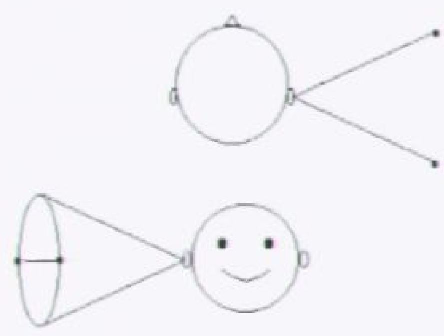

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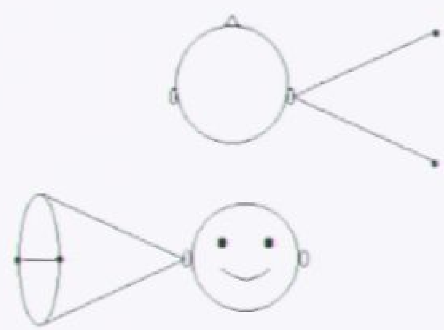

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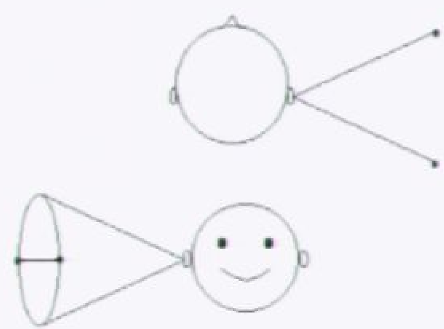

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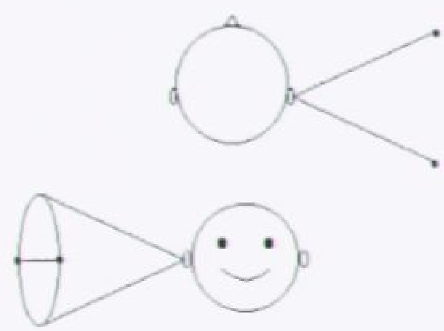

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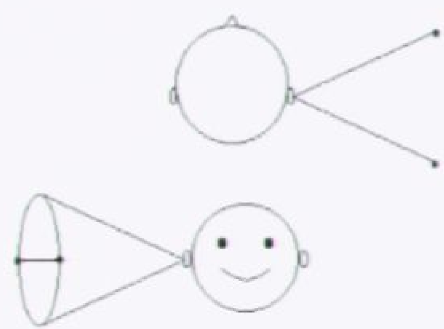

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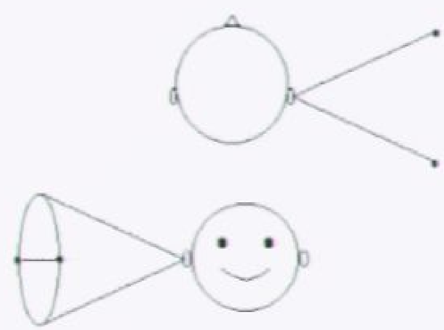

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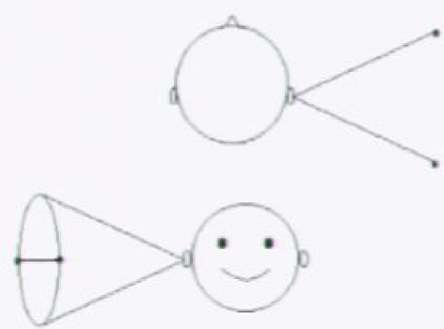

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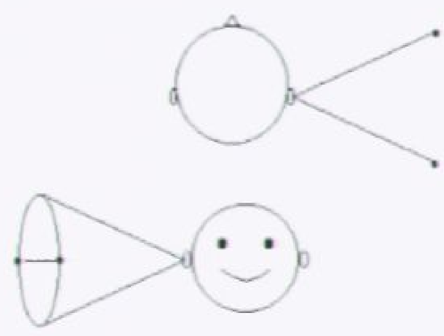

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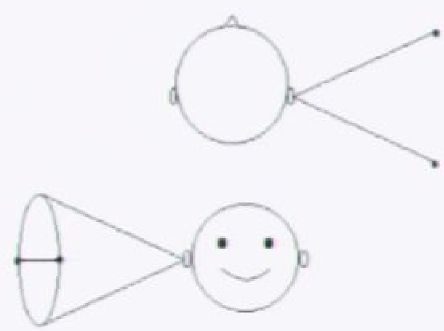

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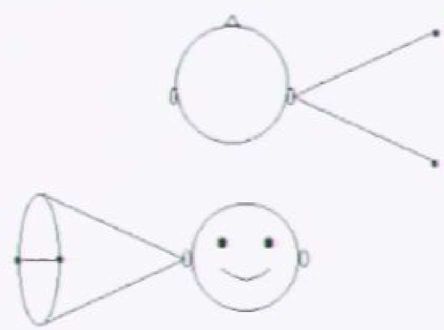

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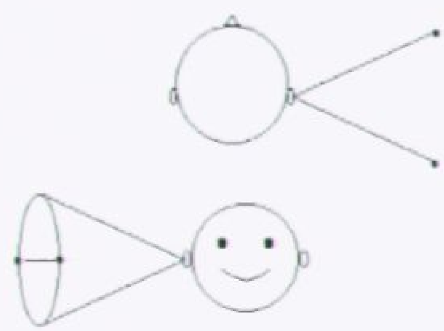

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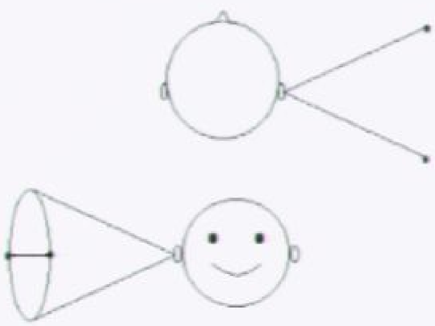

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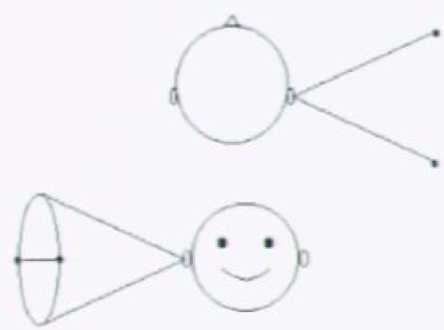

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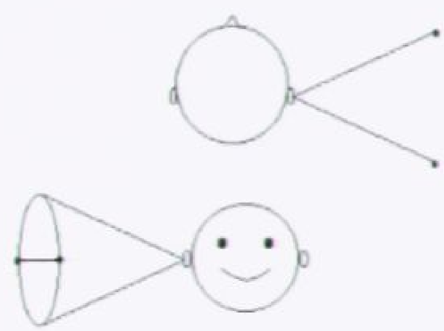

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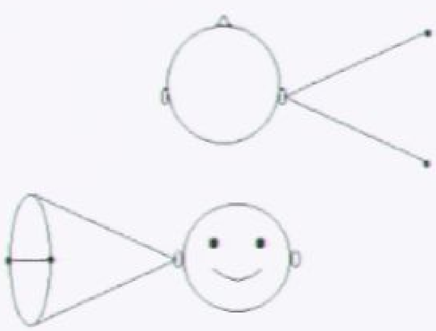

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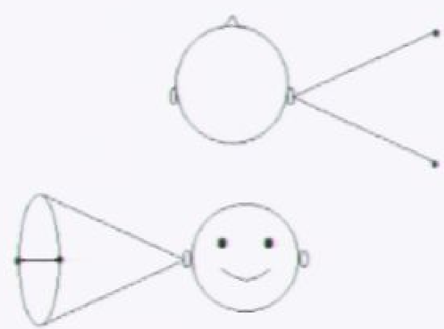

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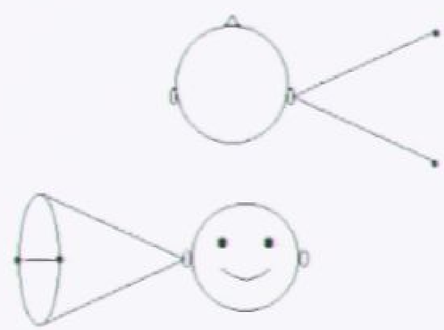

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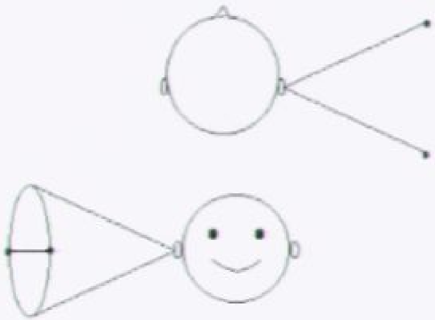

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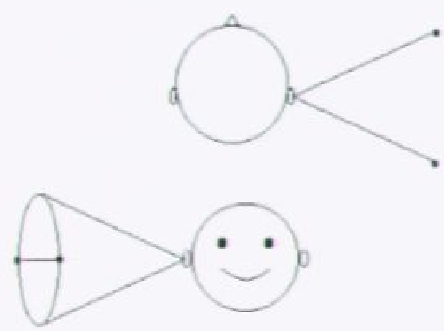

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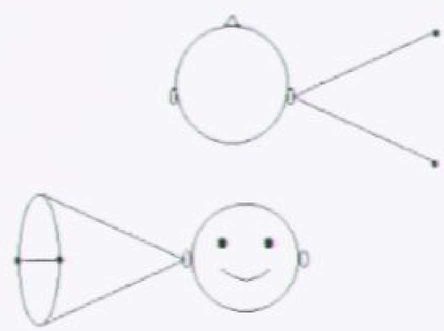

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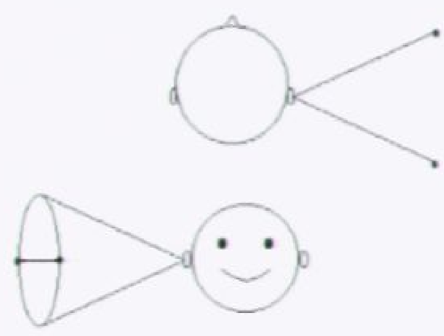

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- Unique for each person and sound source location
- Take into account spectral filtering of torso, head, pinna, etc.

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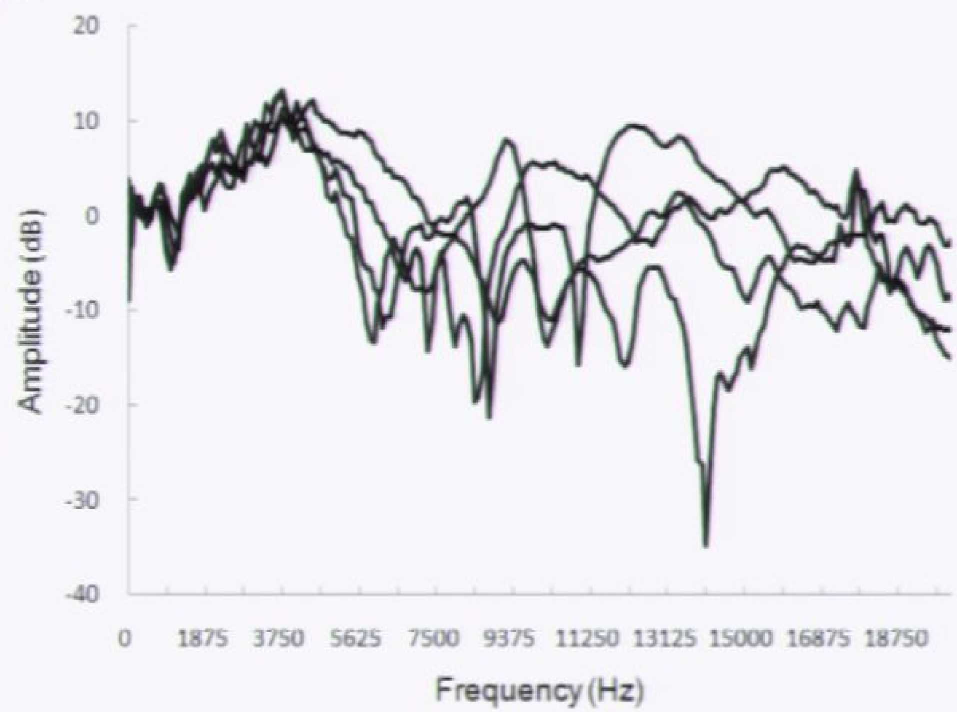

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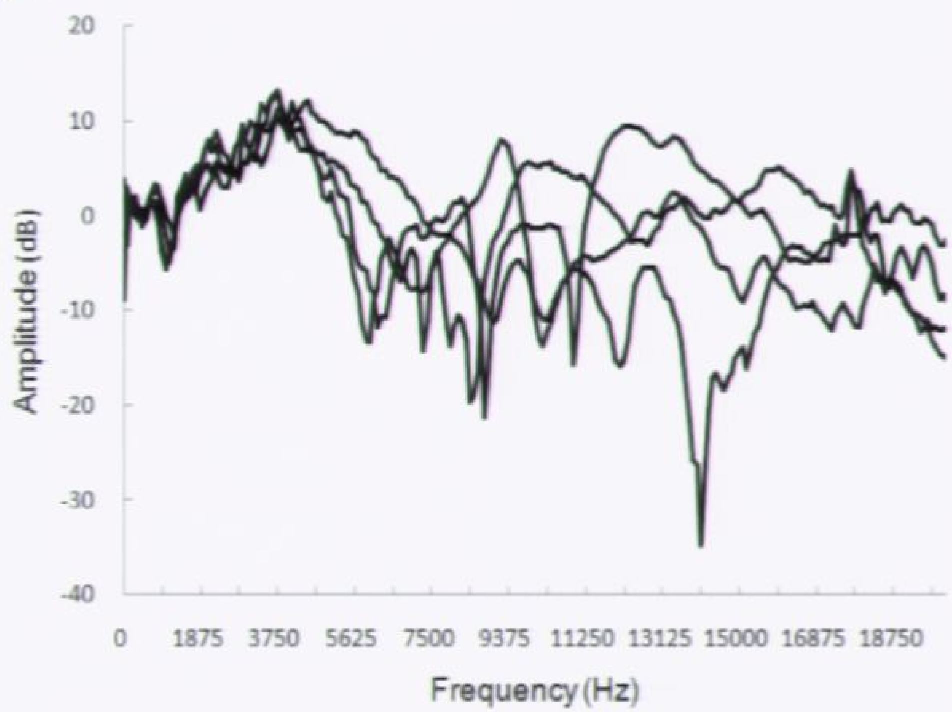

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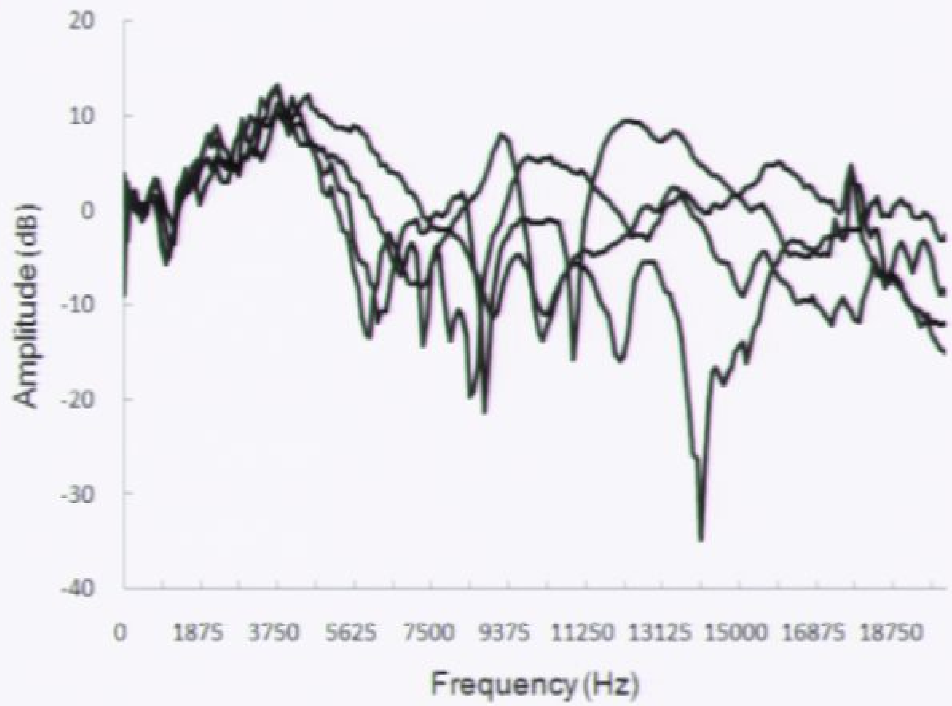

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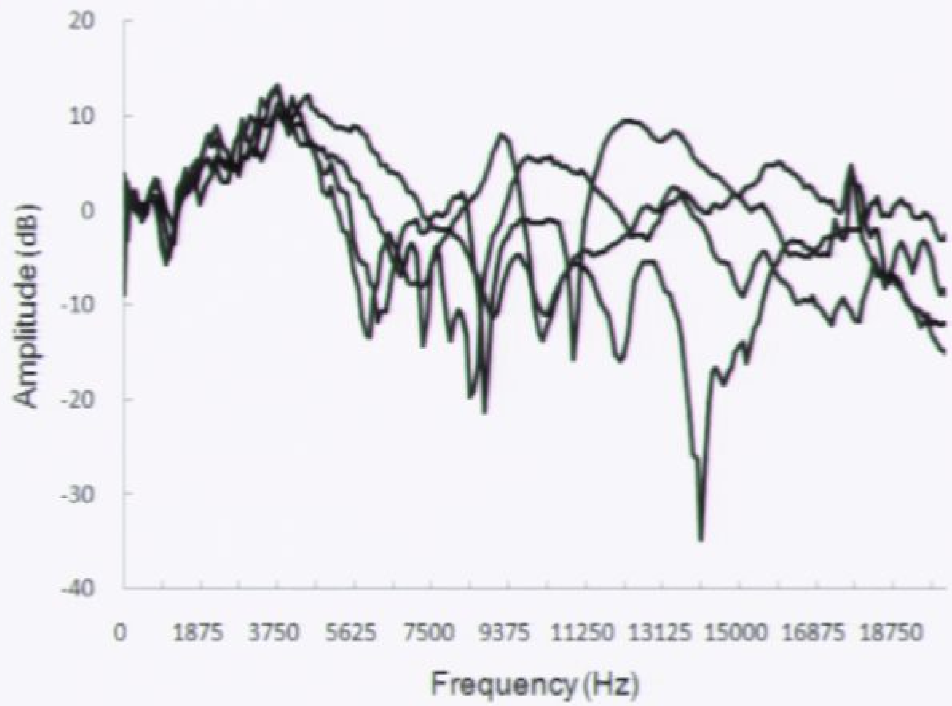

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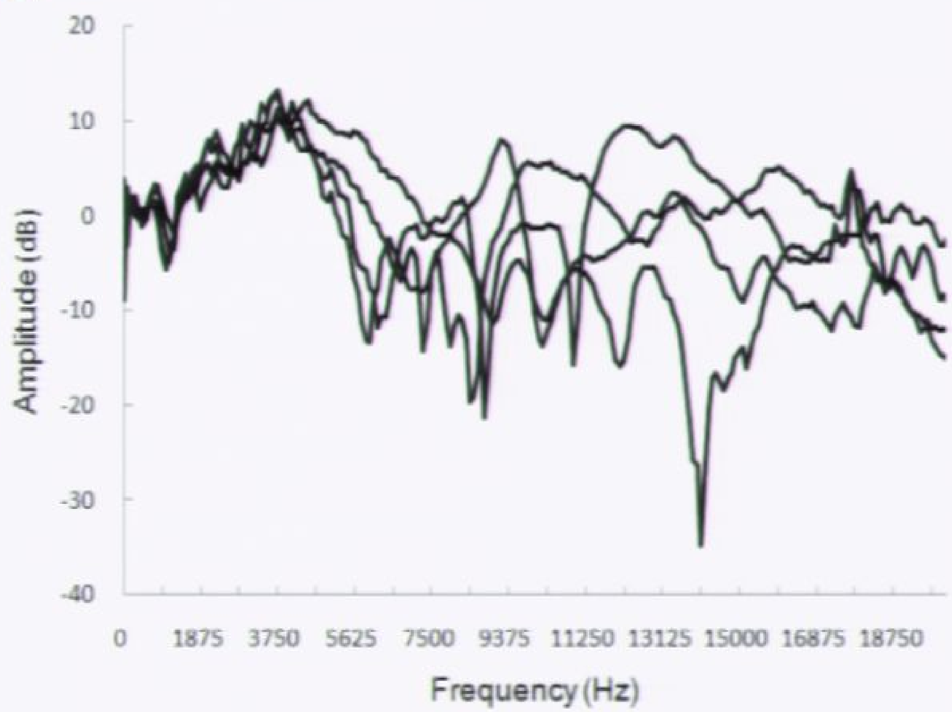

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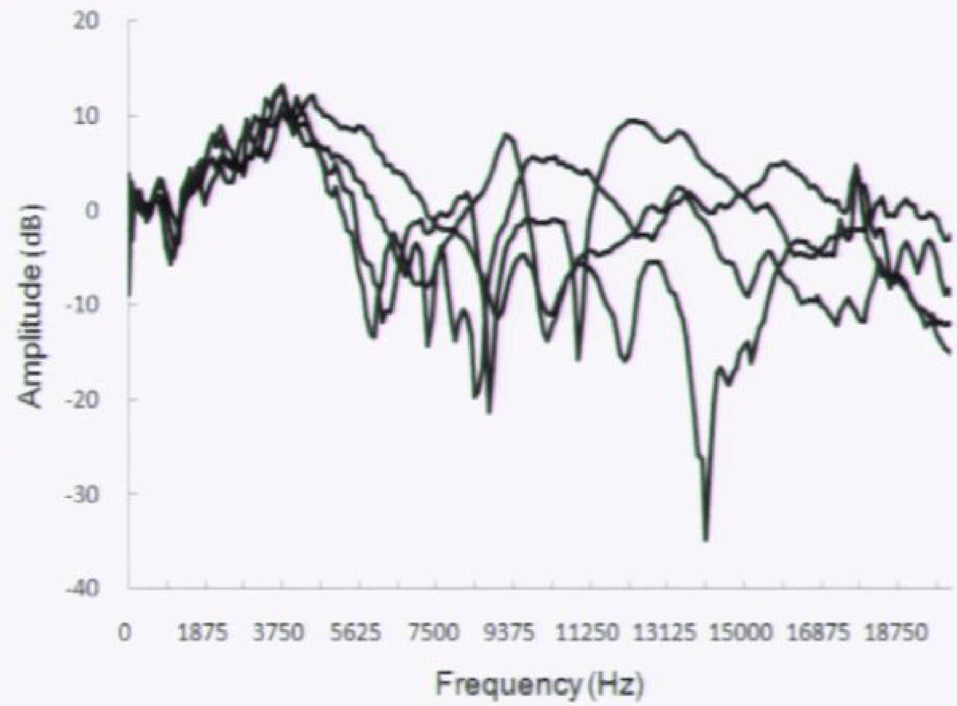

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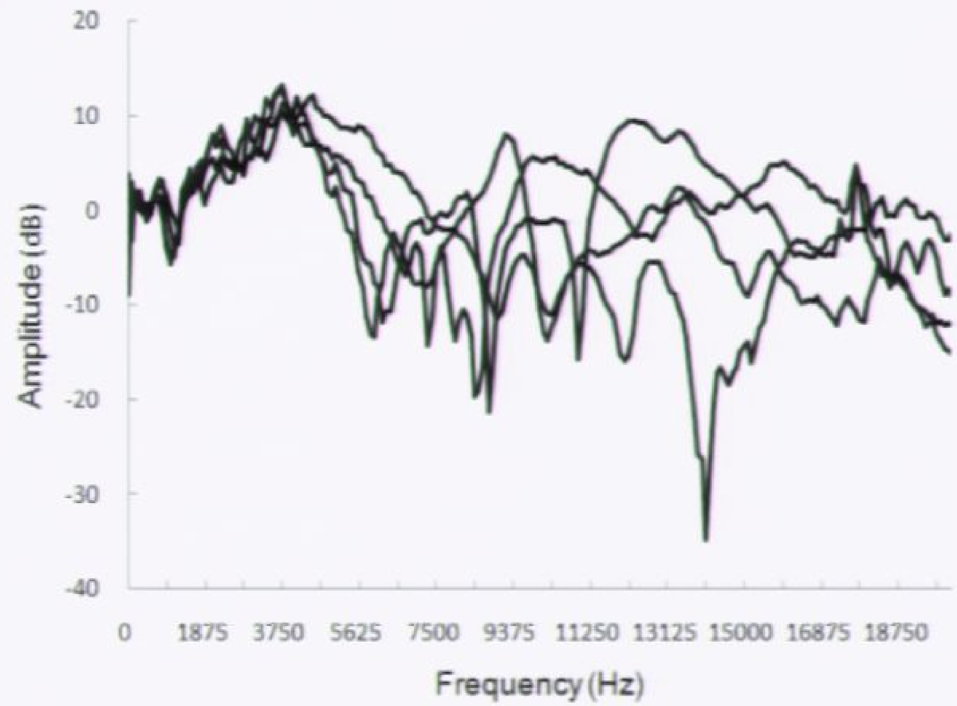

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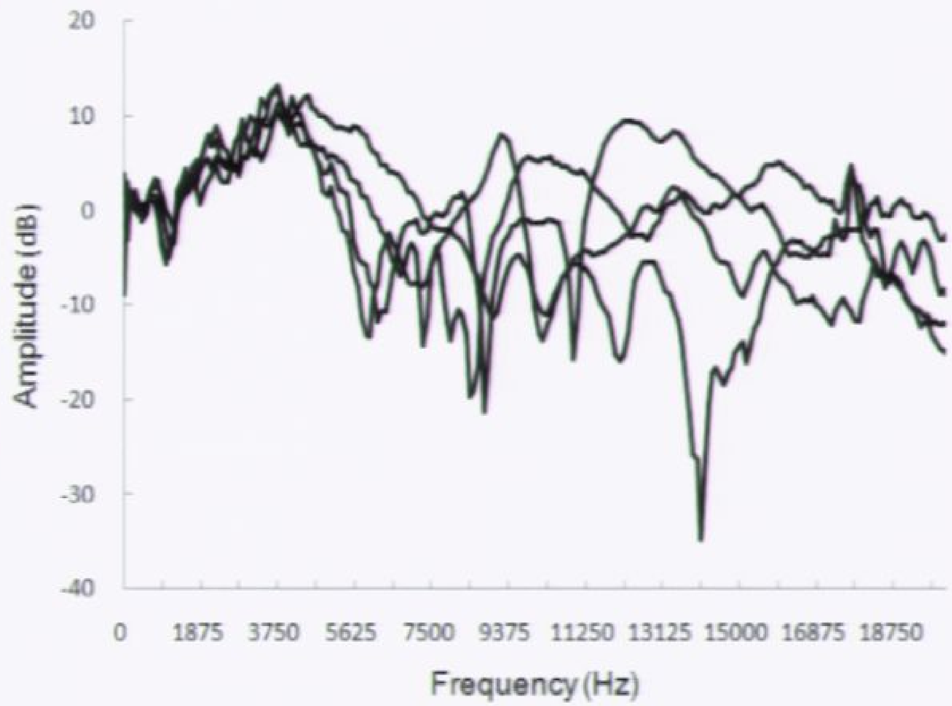

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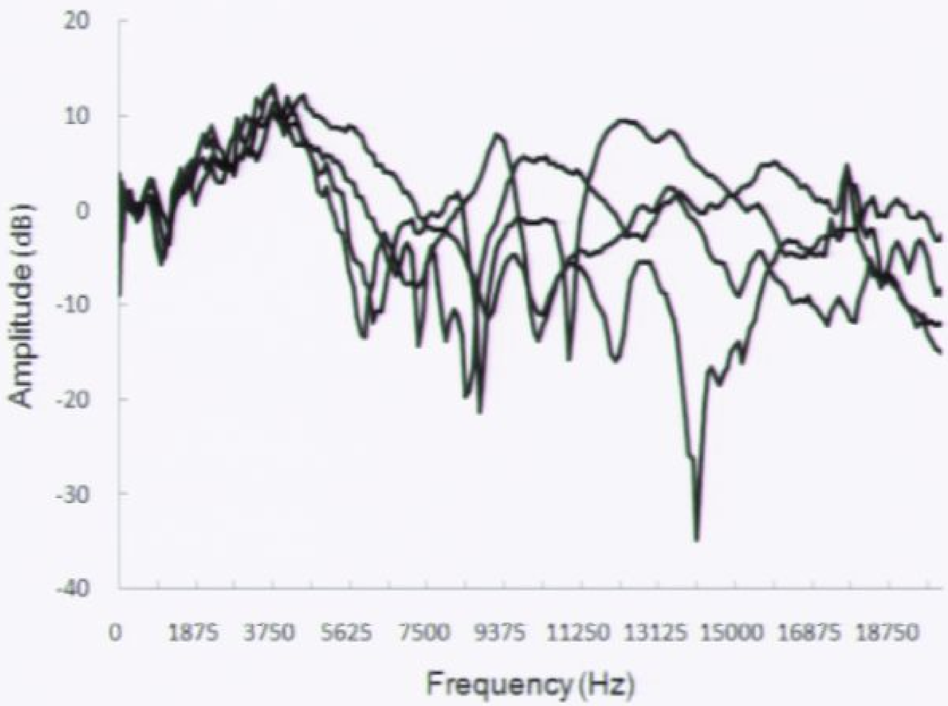

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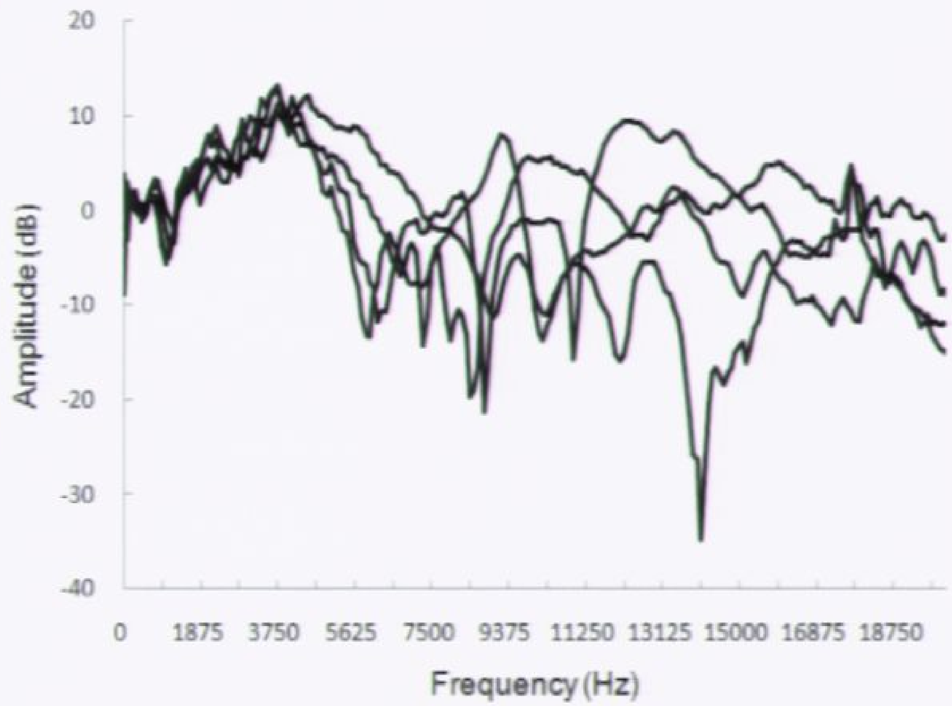

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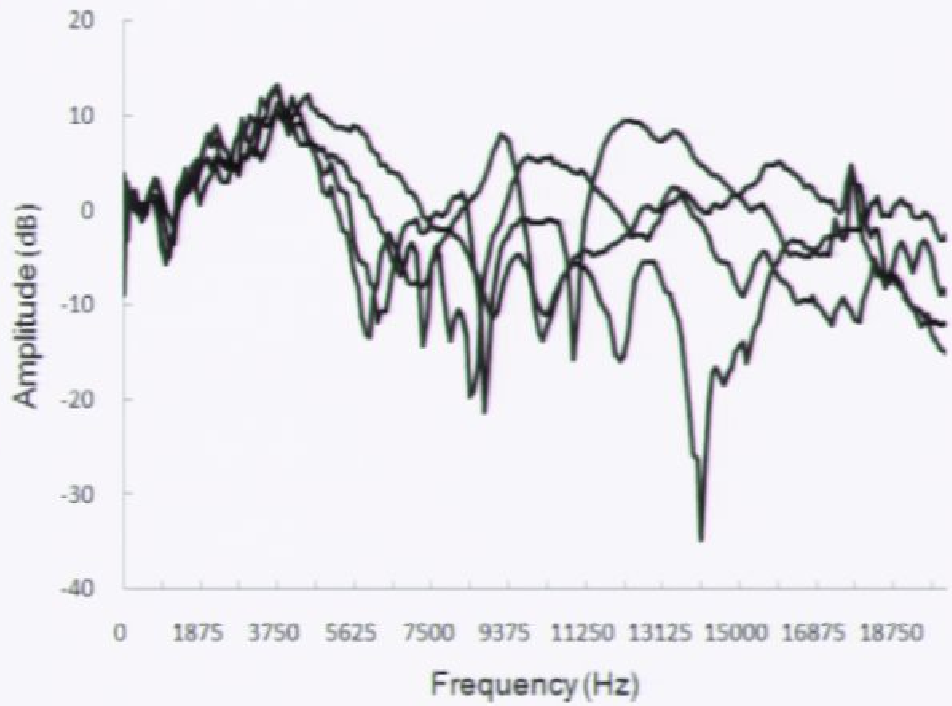

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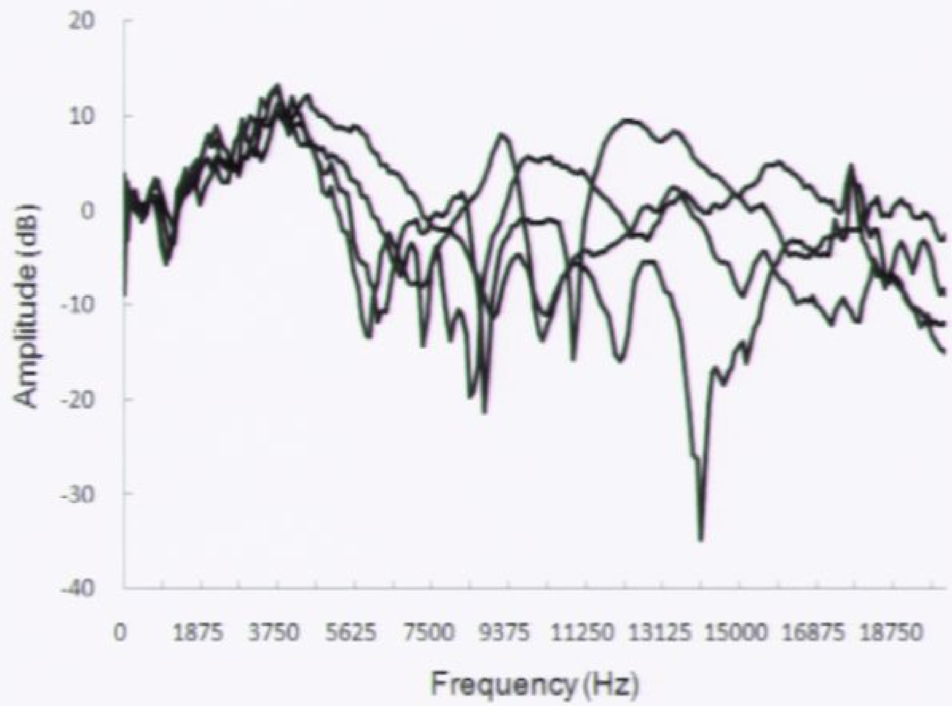

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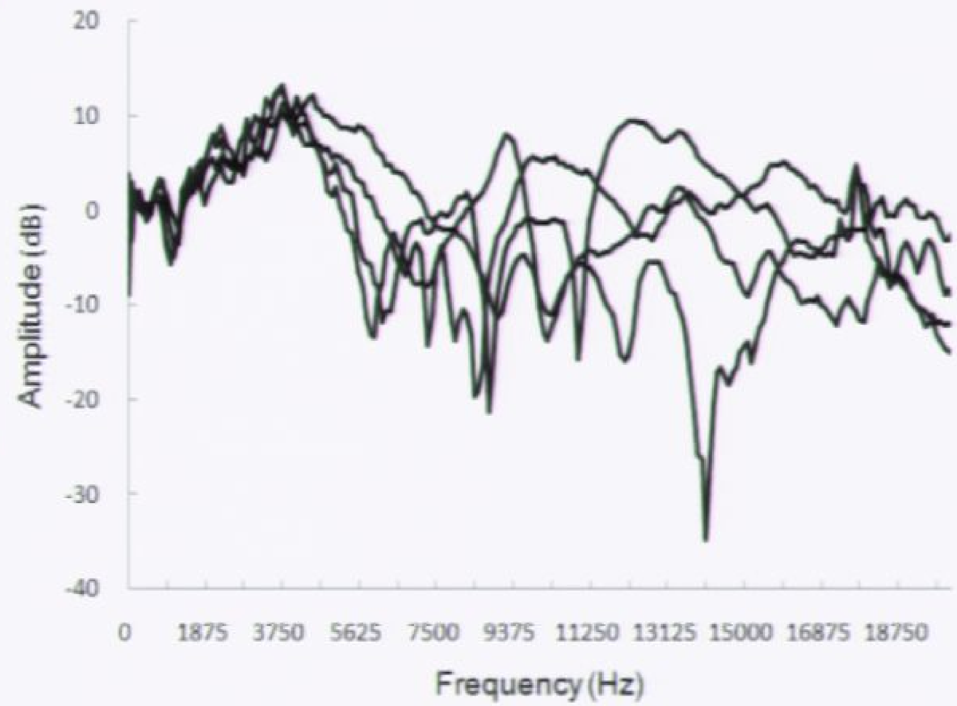

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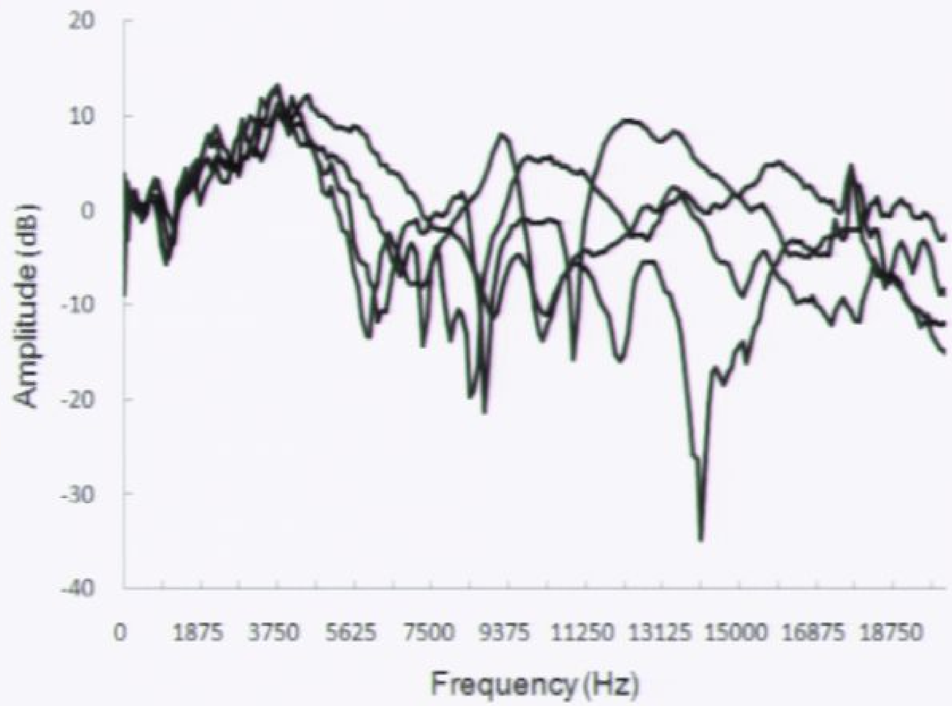

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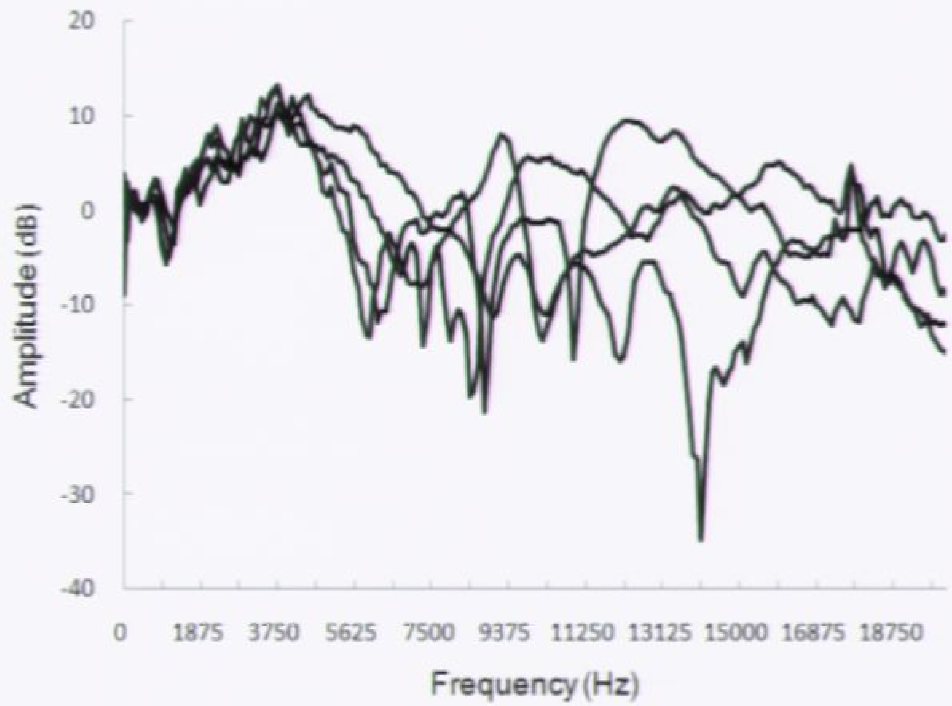

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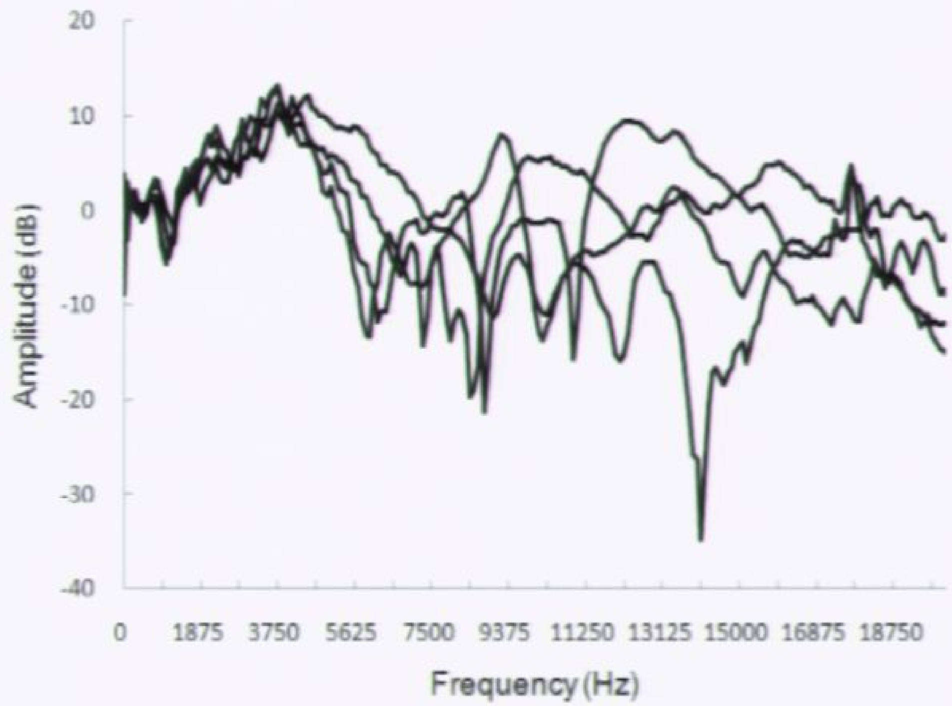

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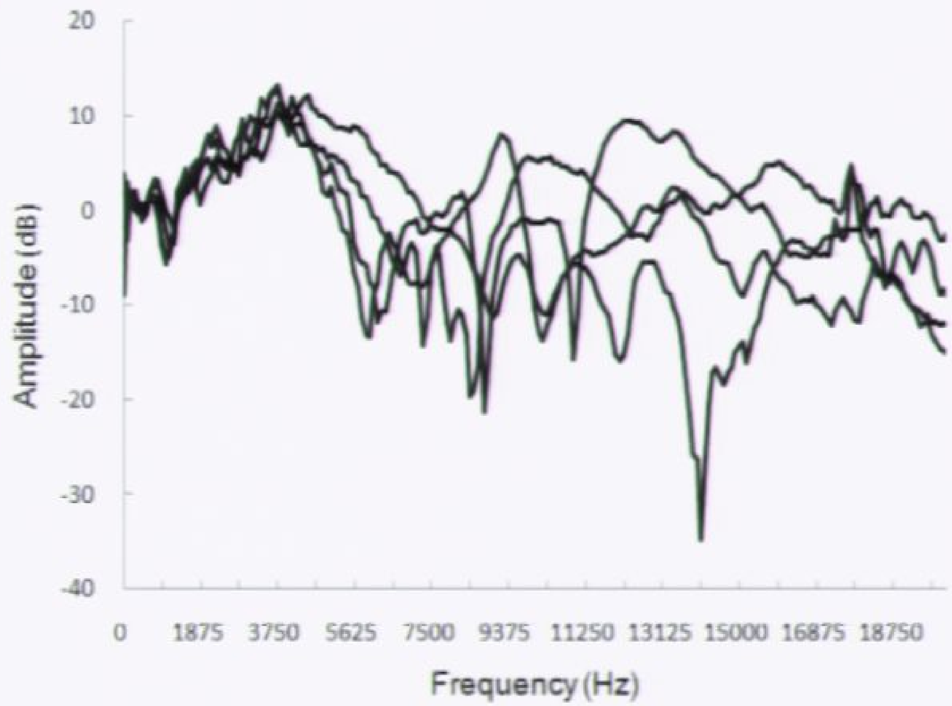

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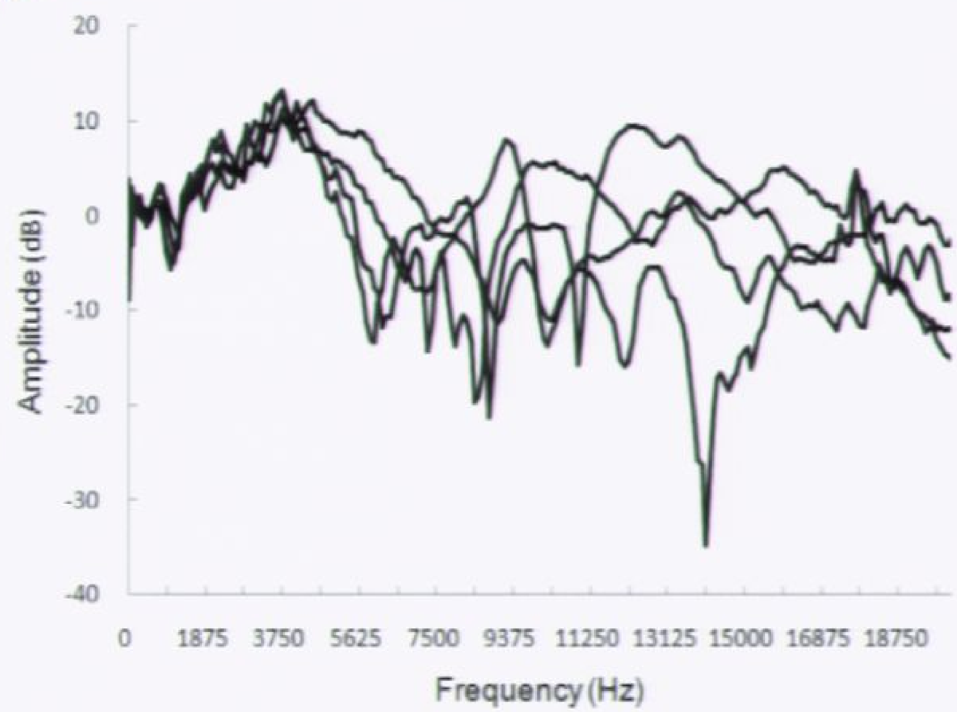

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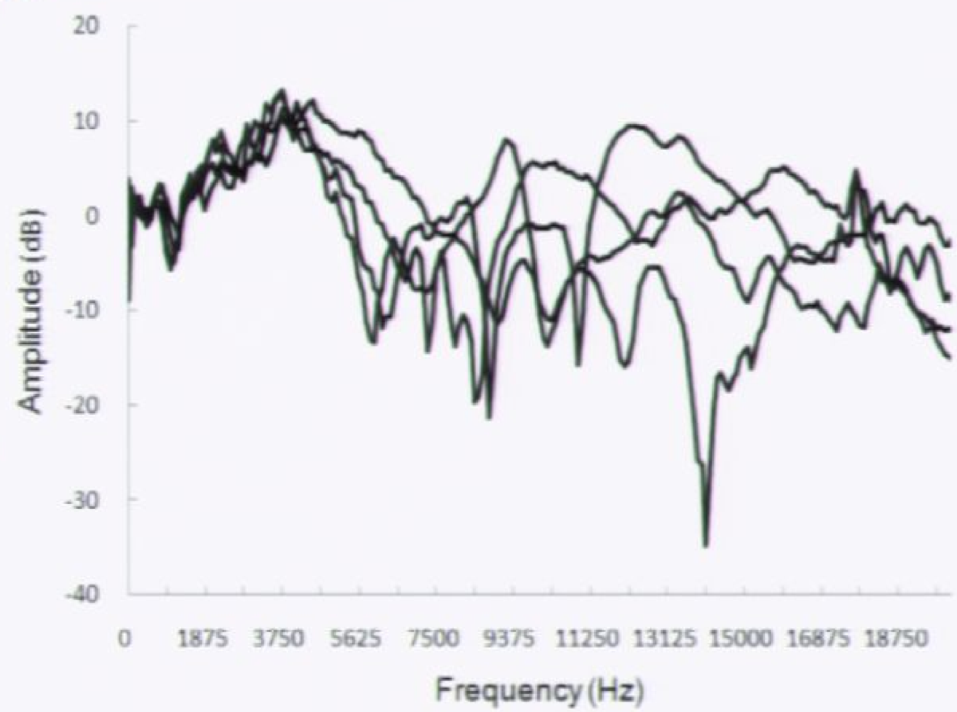

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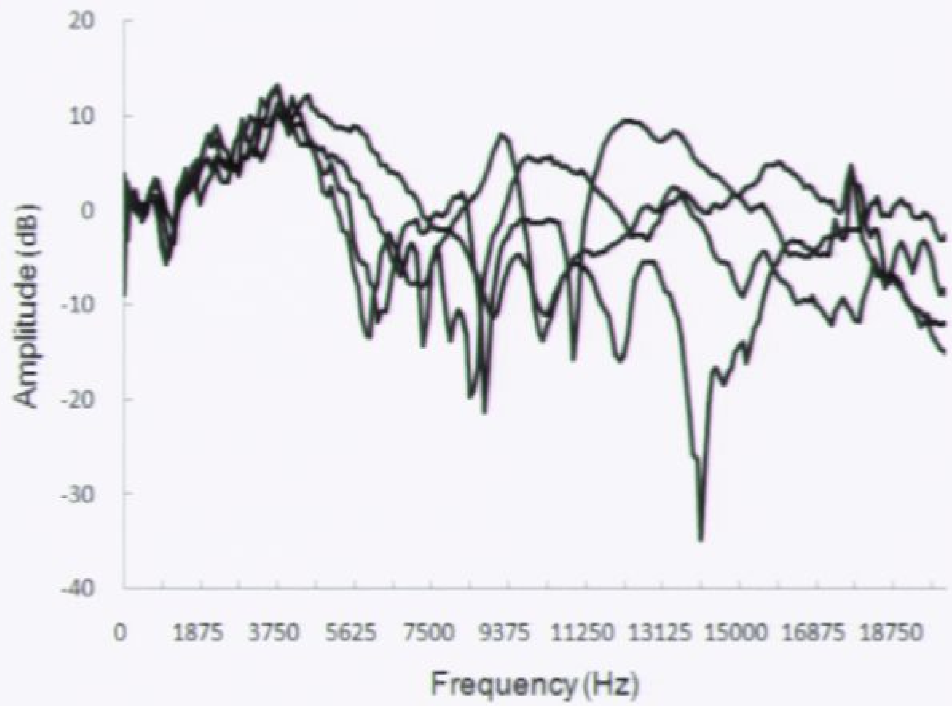

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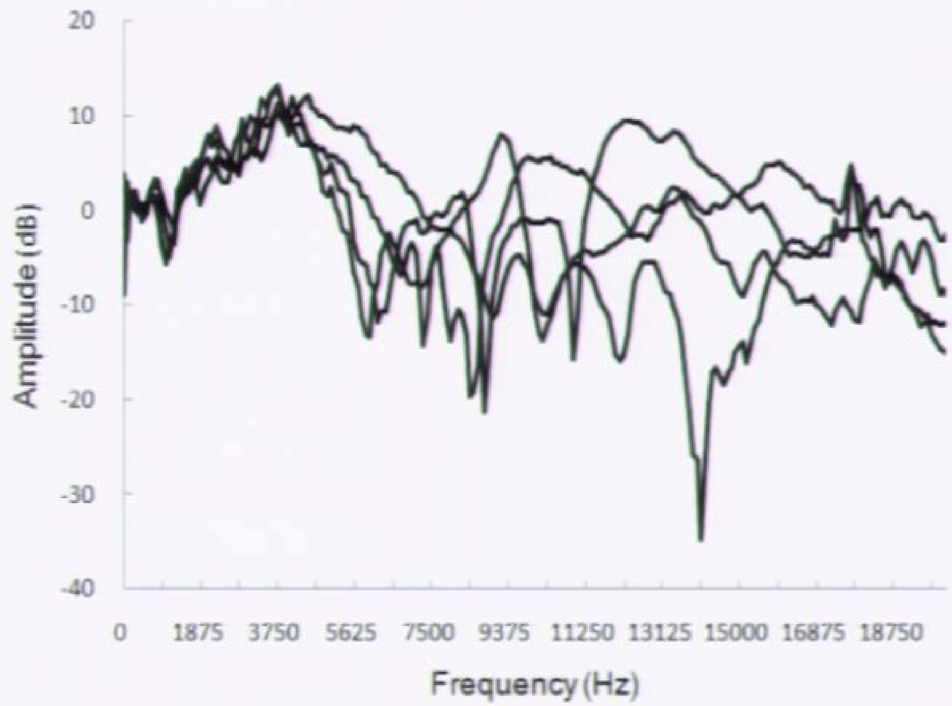

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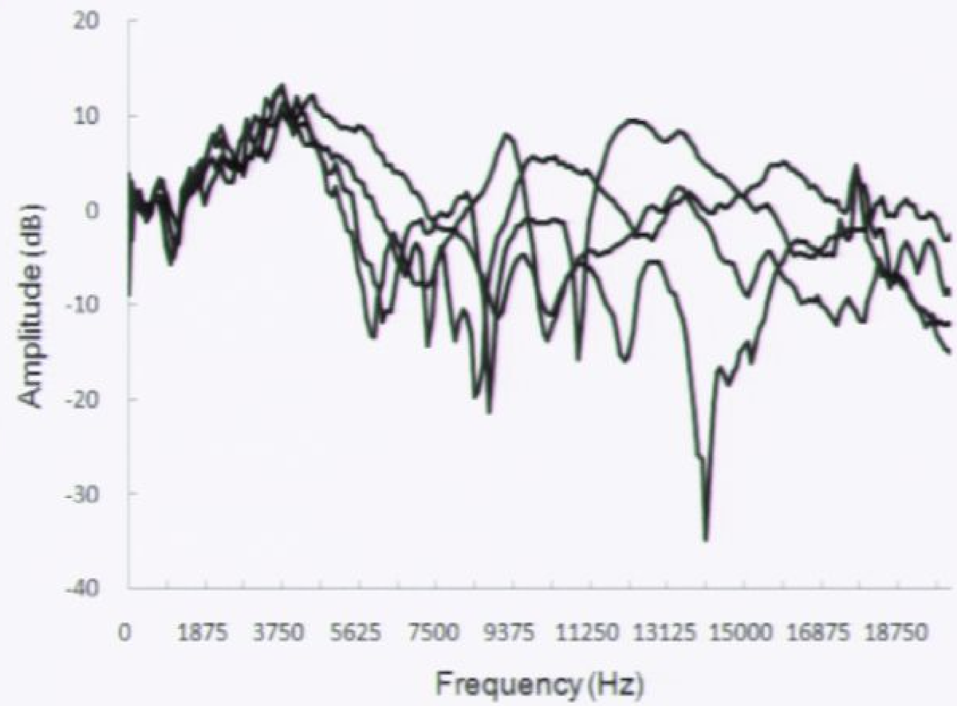

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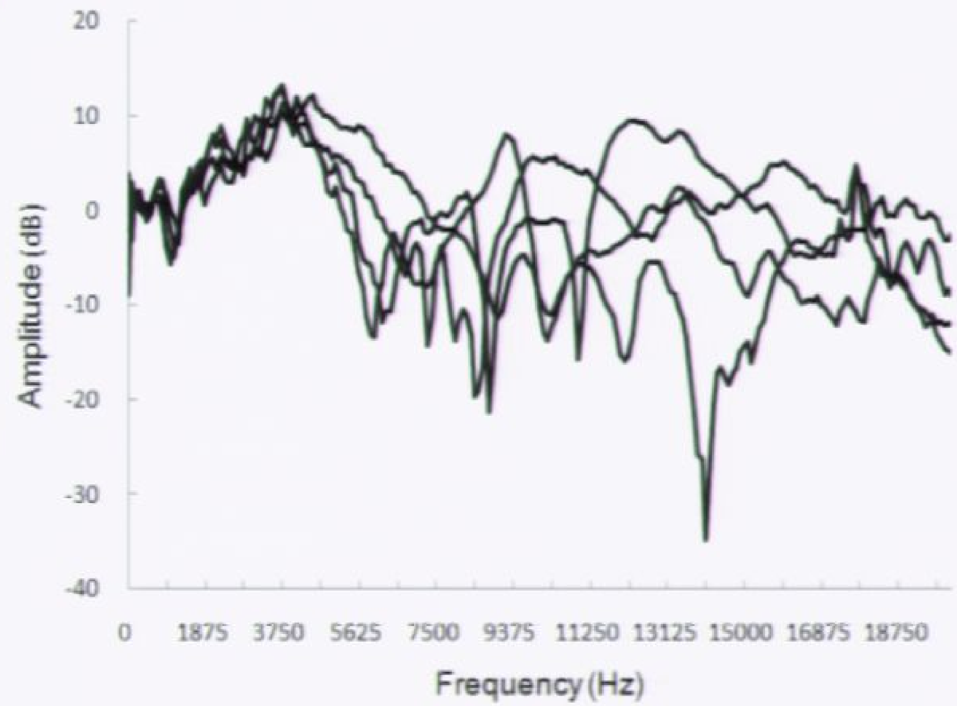

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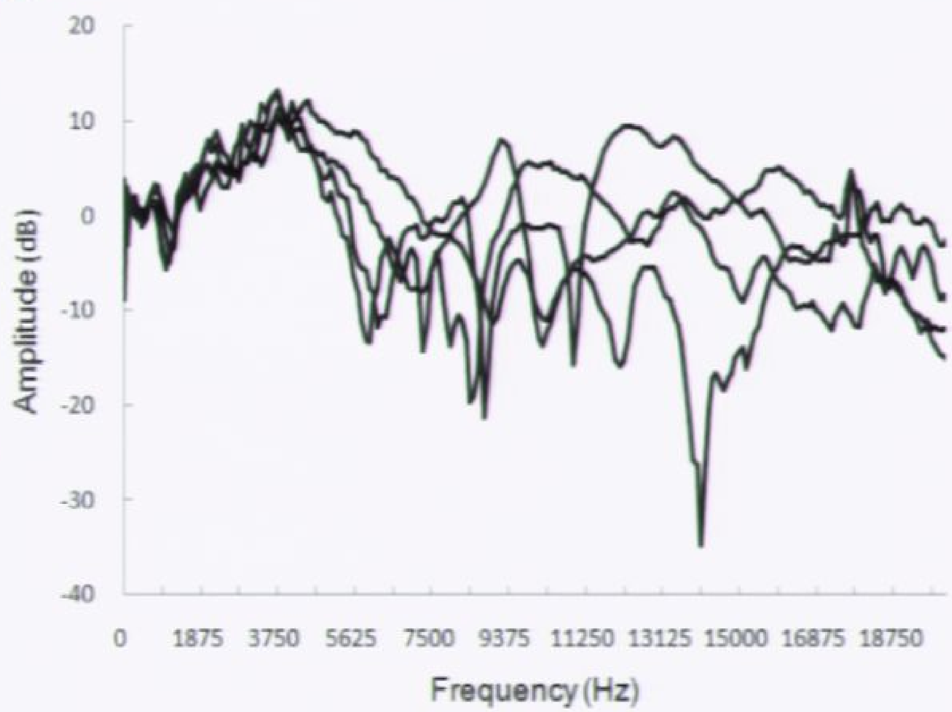

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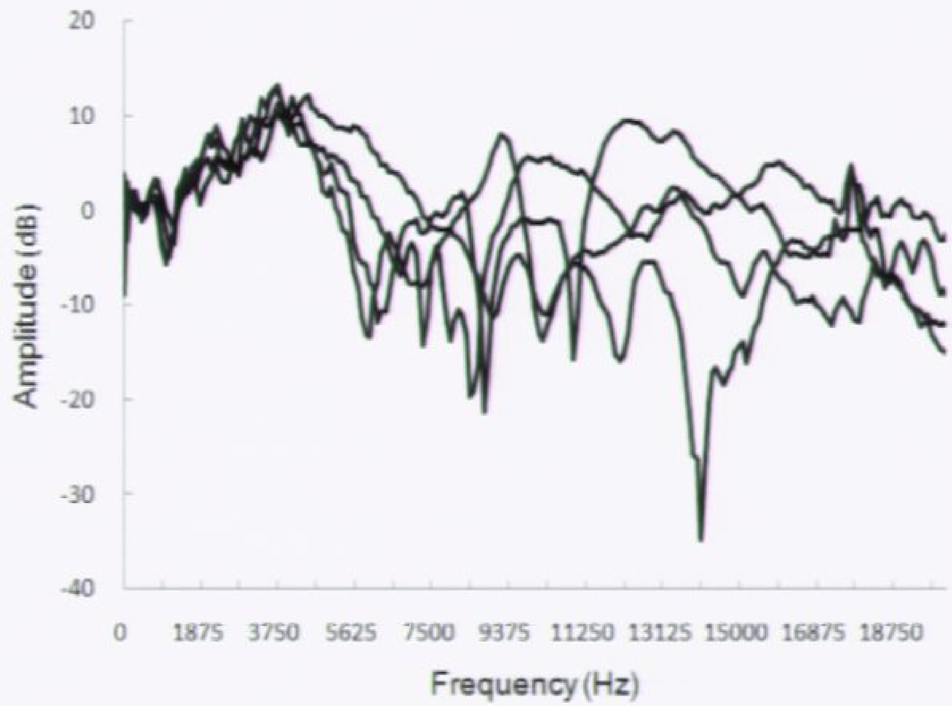

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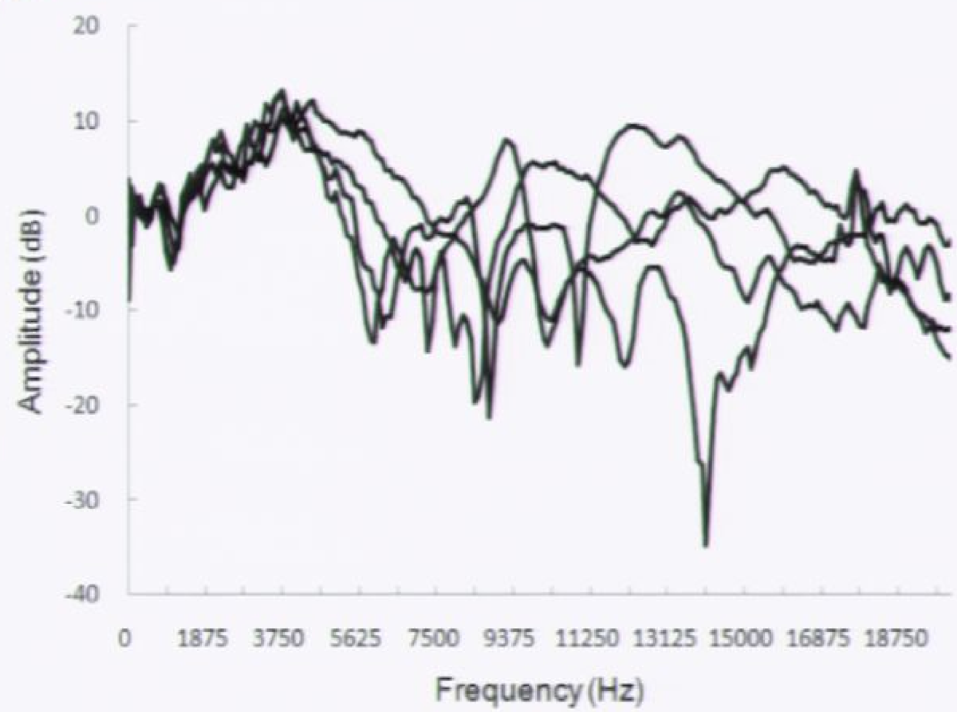

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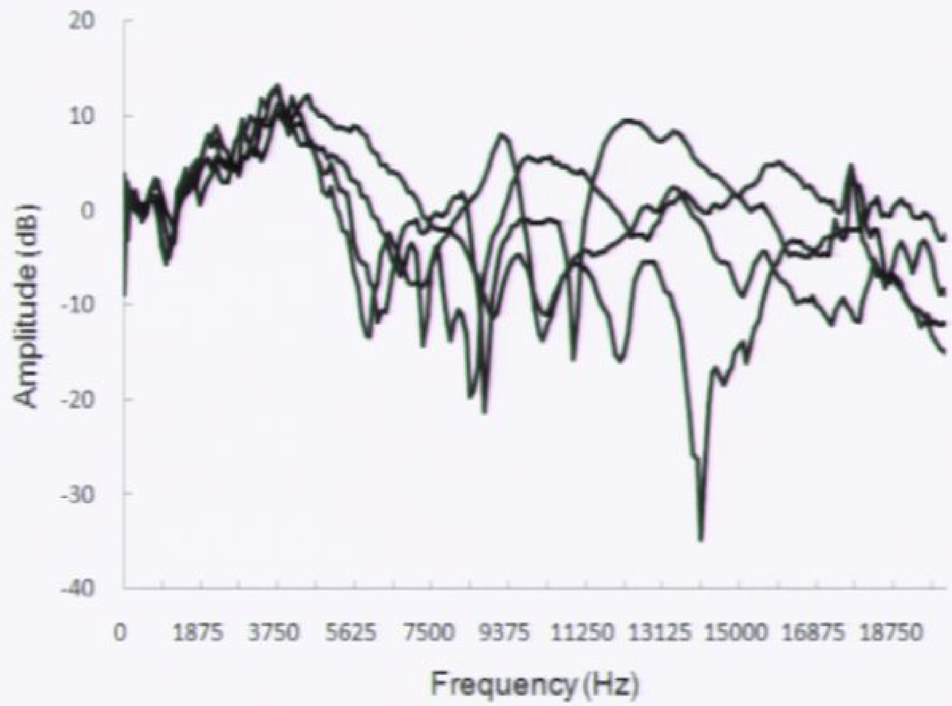

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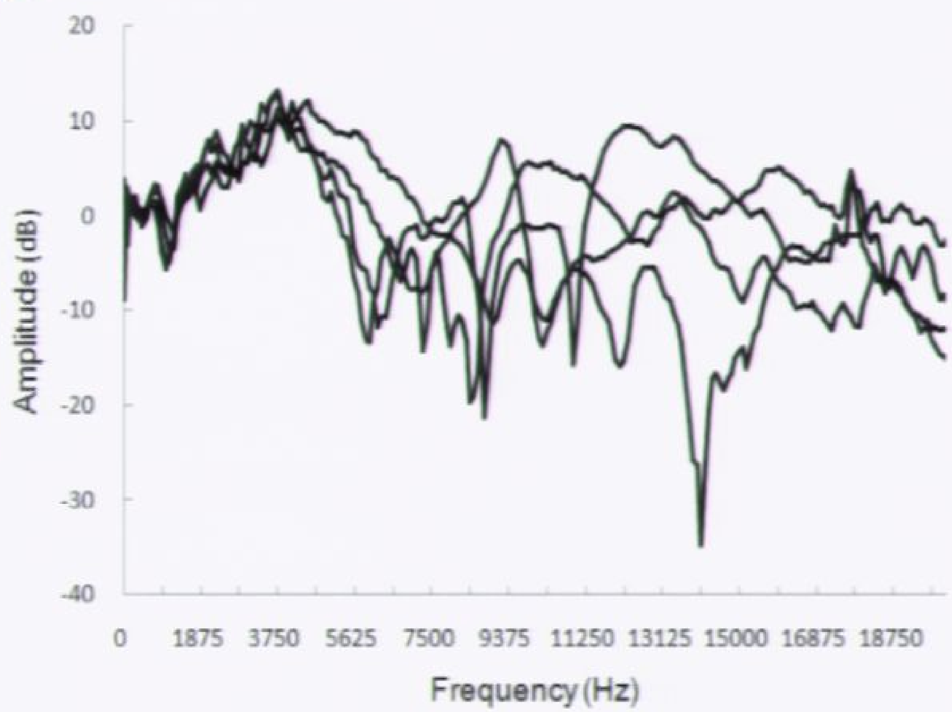

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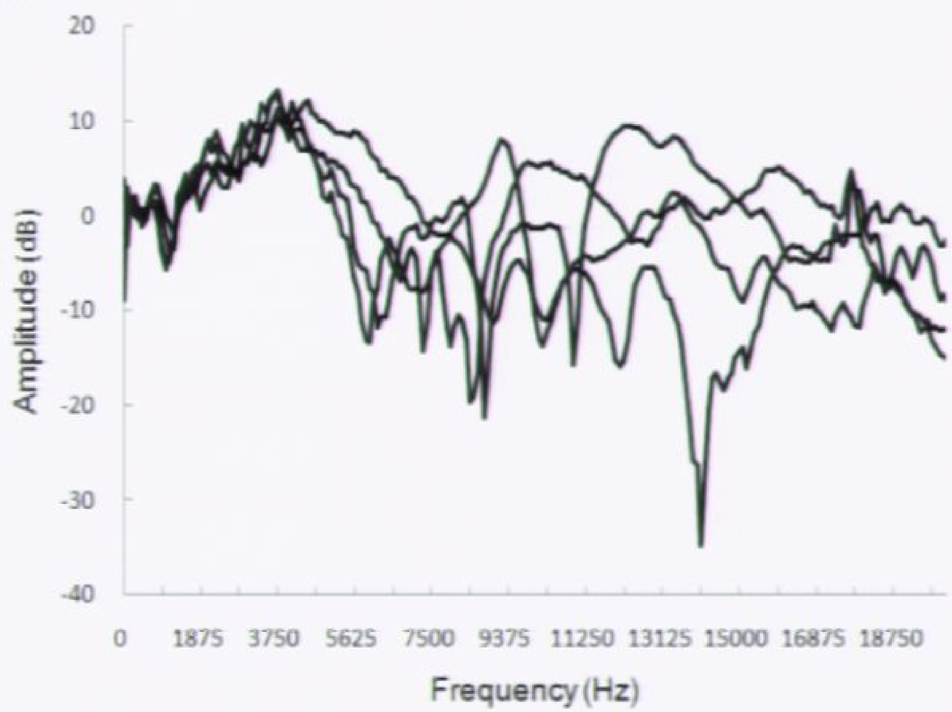

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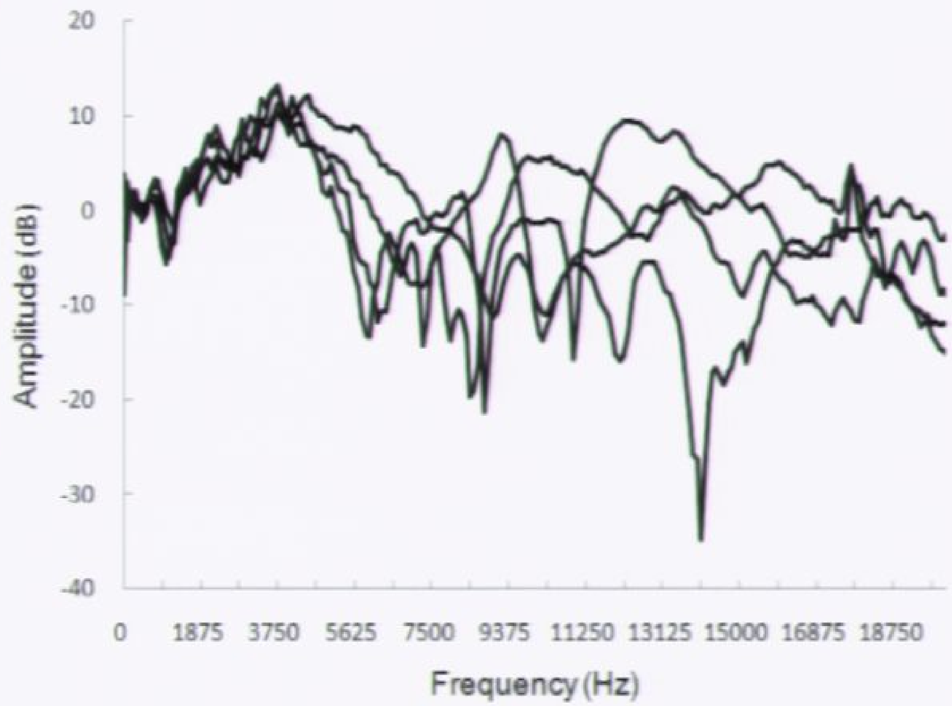

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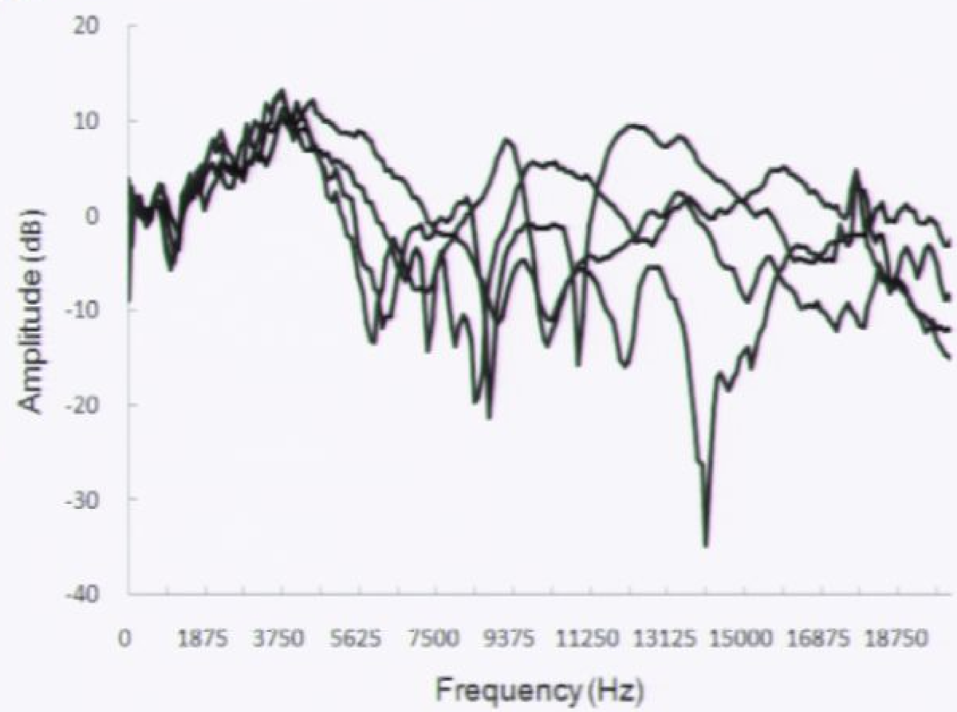

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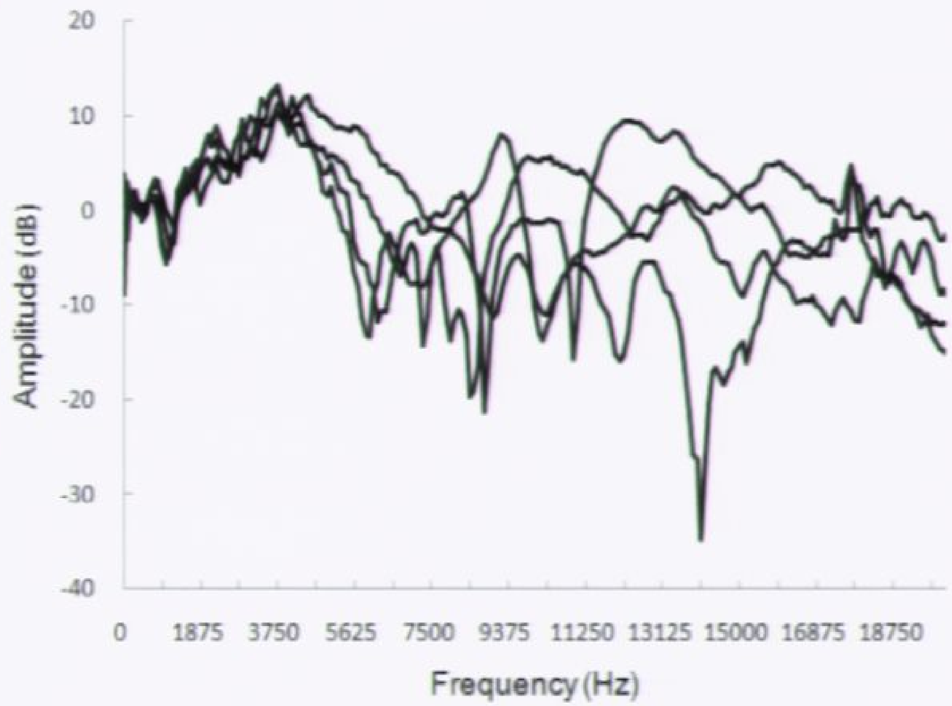

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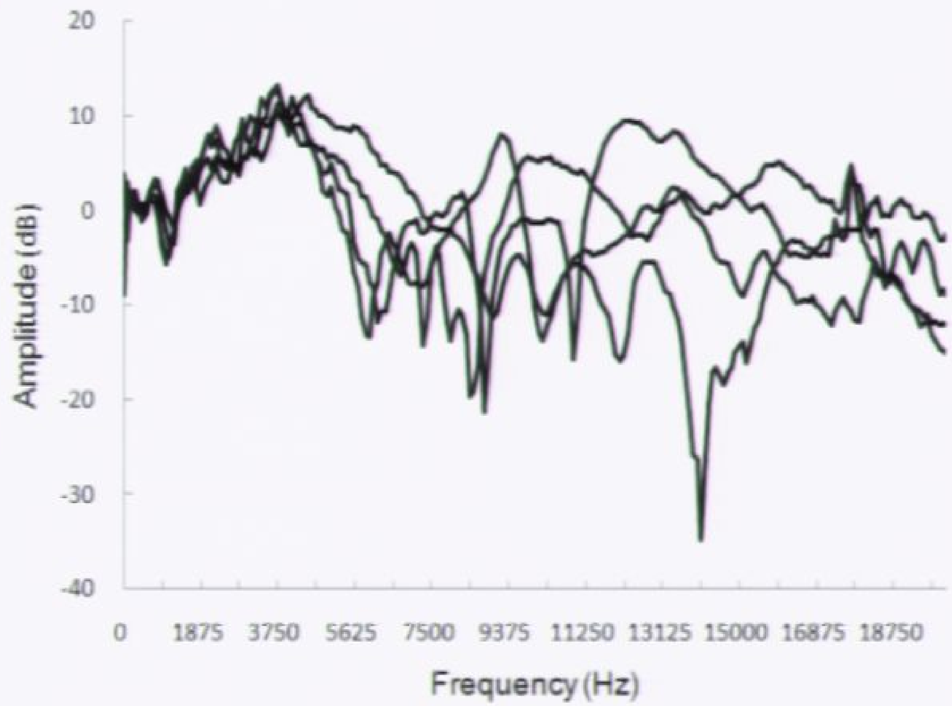

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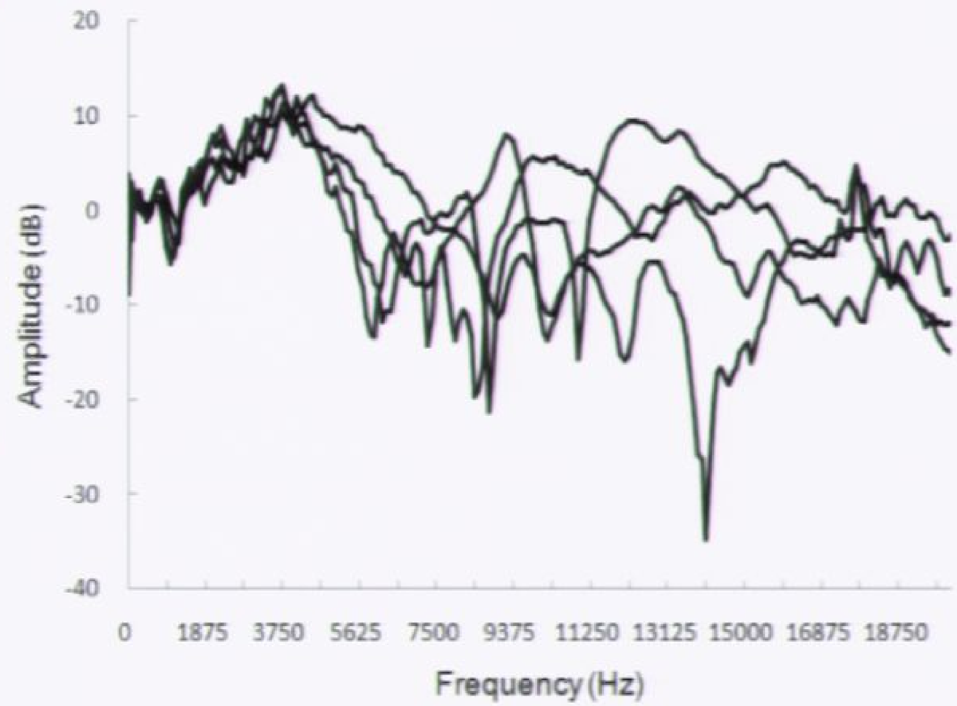

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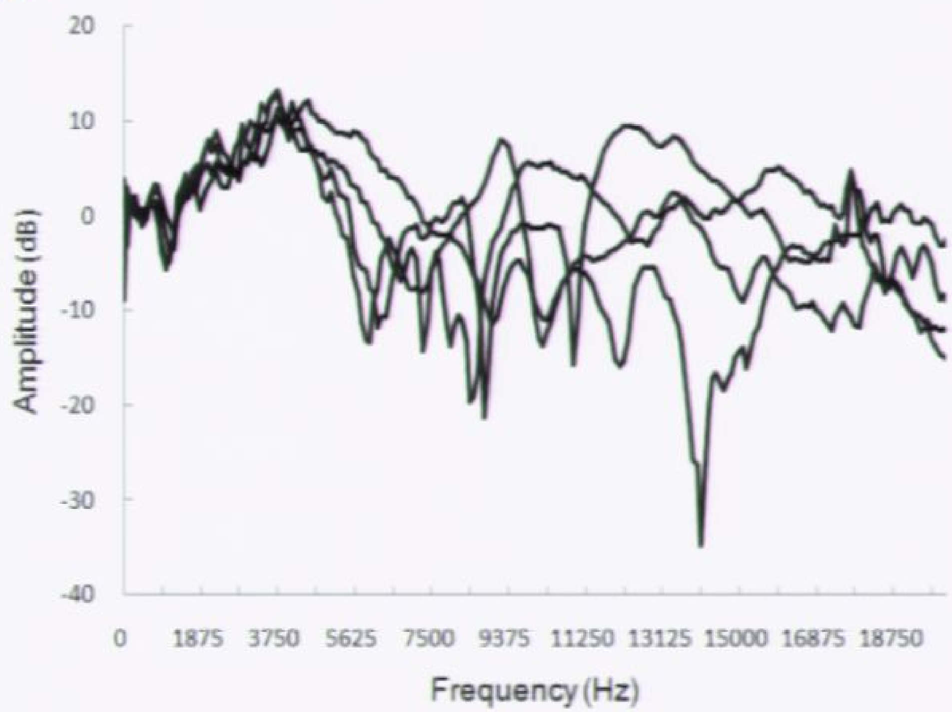

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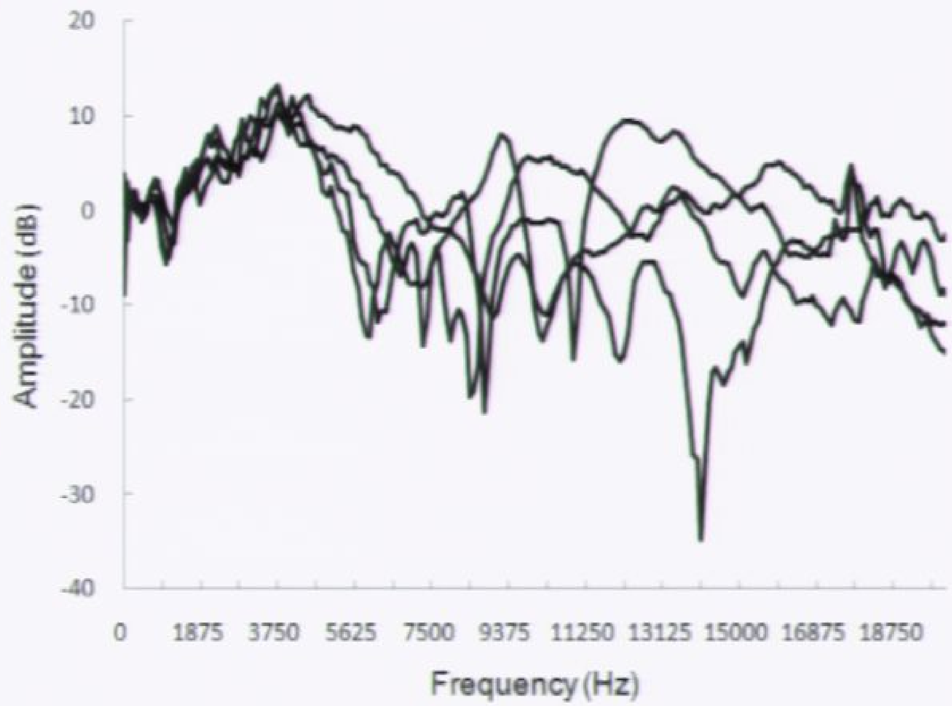

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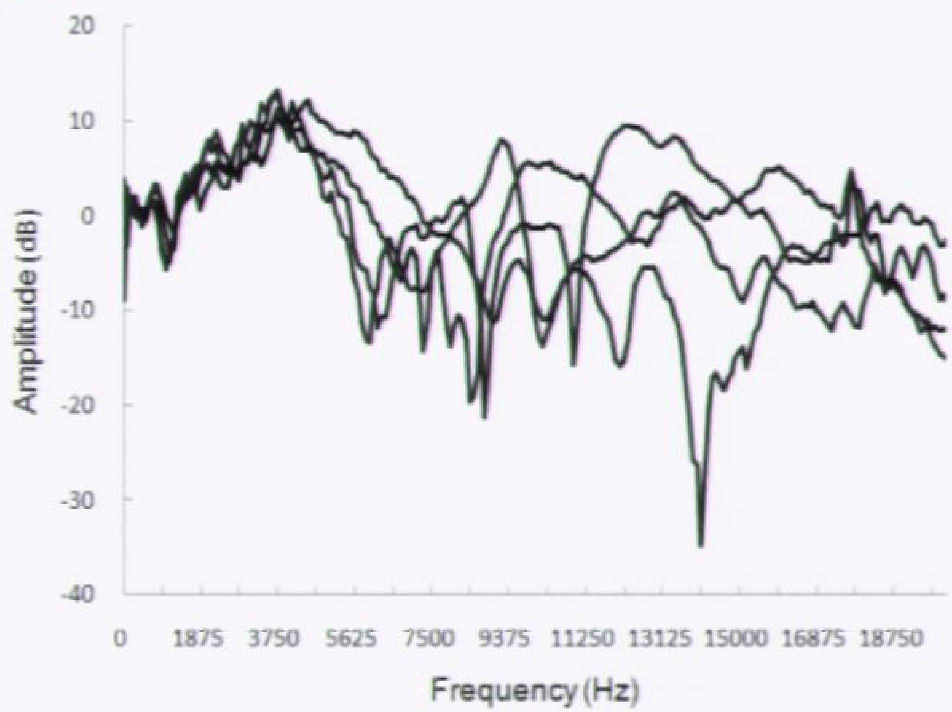

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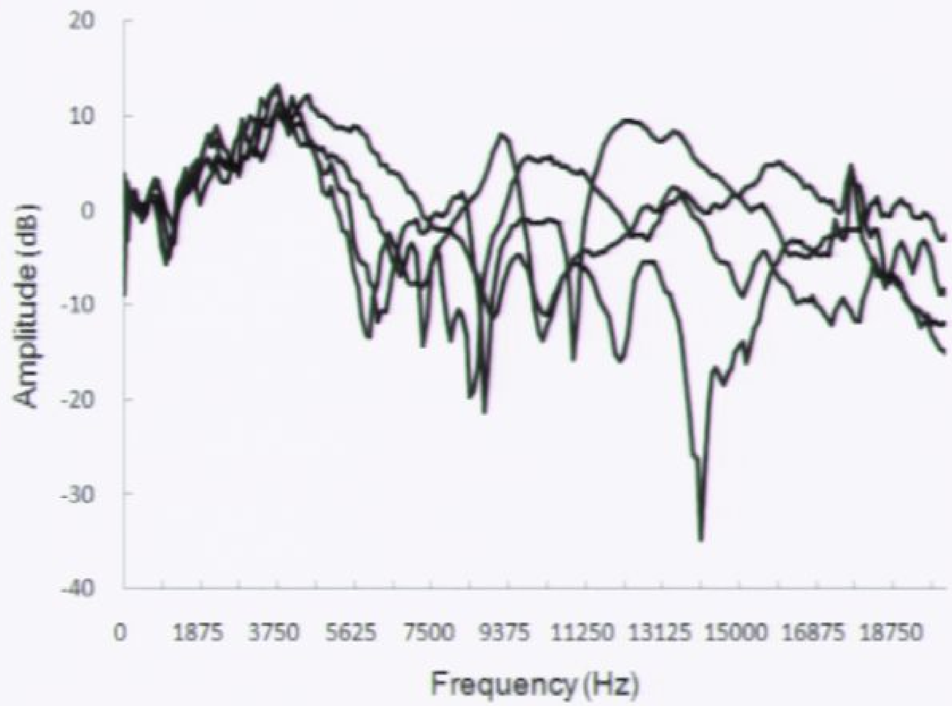

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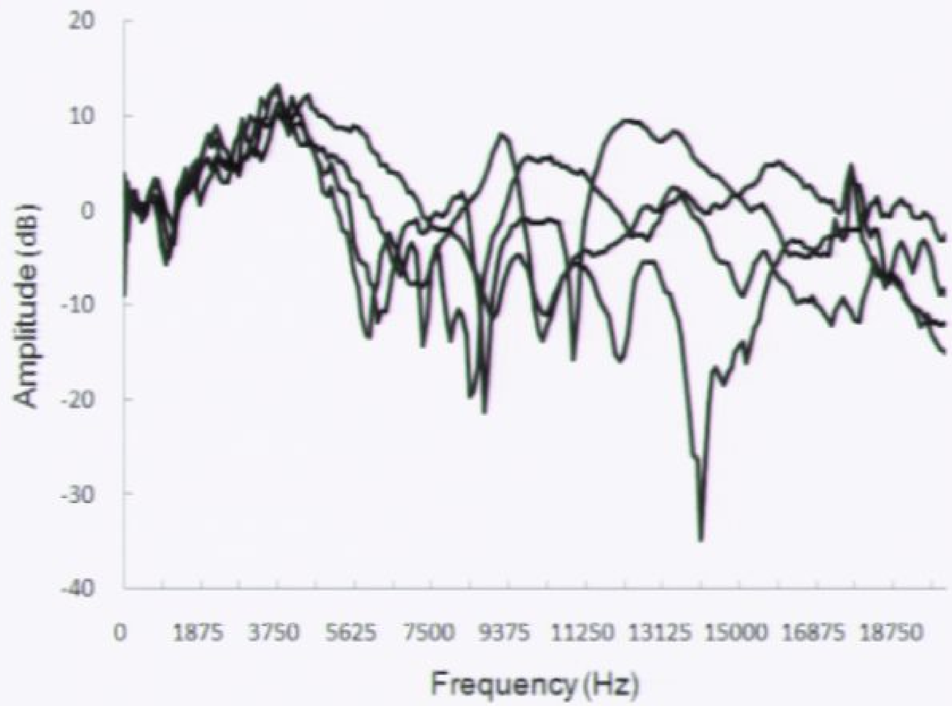

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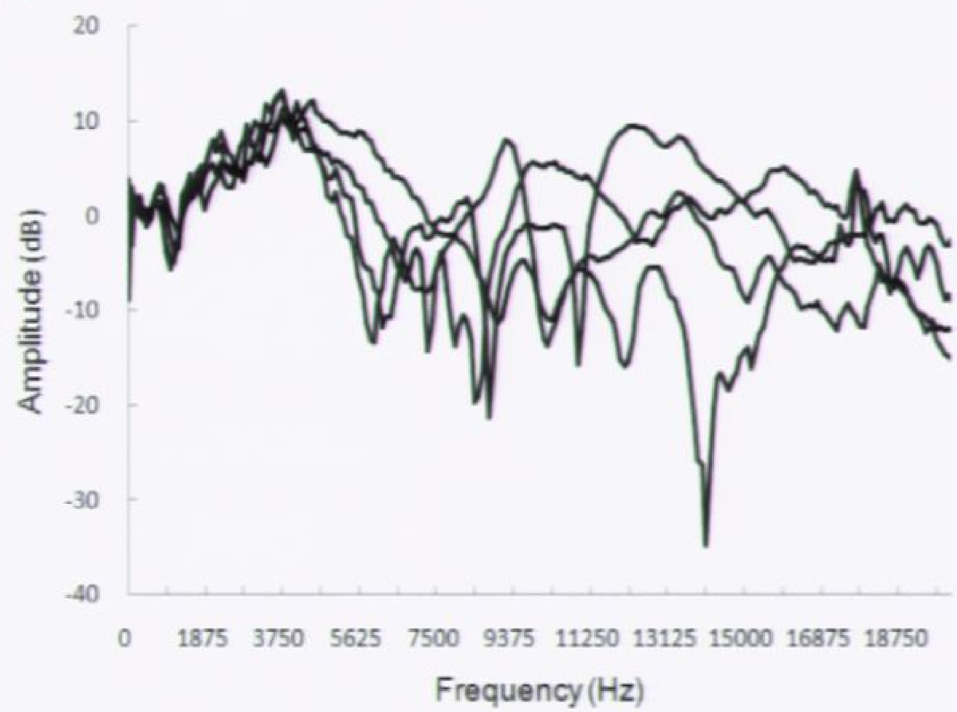

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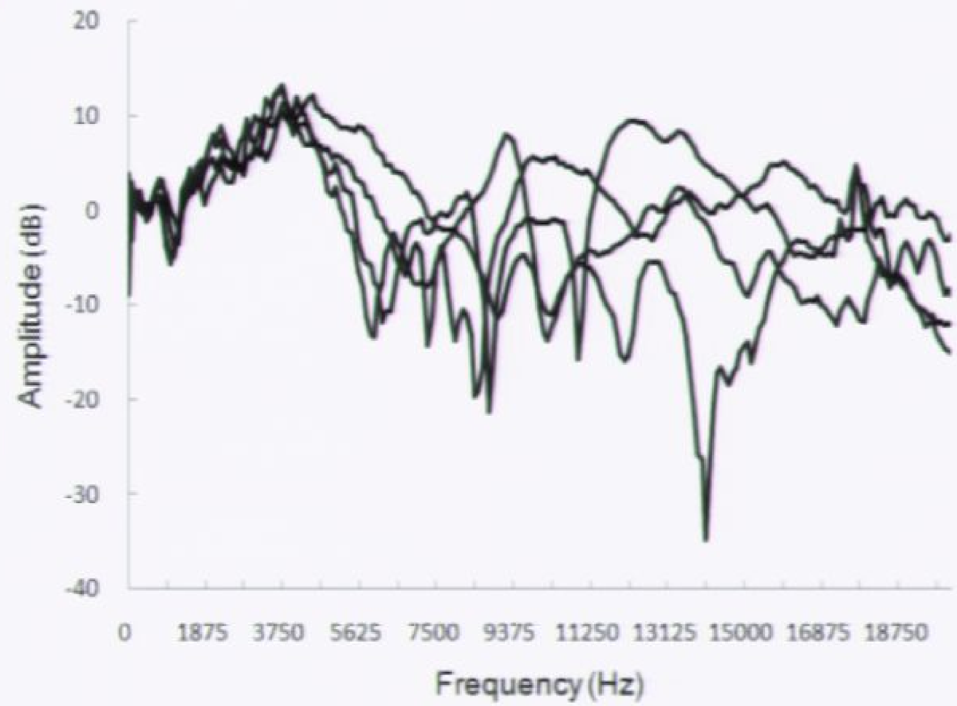

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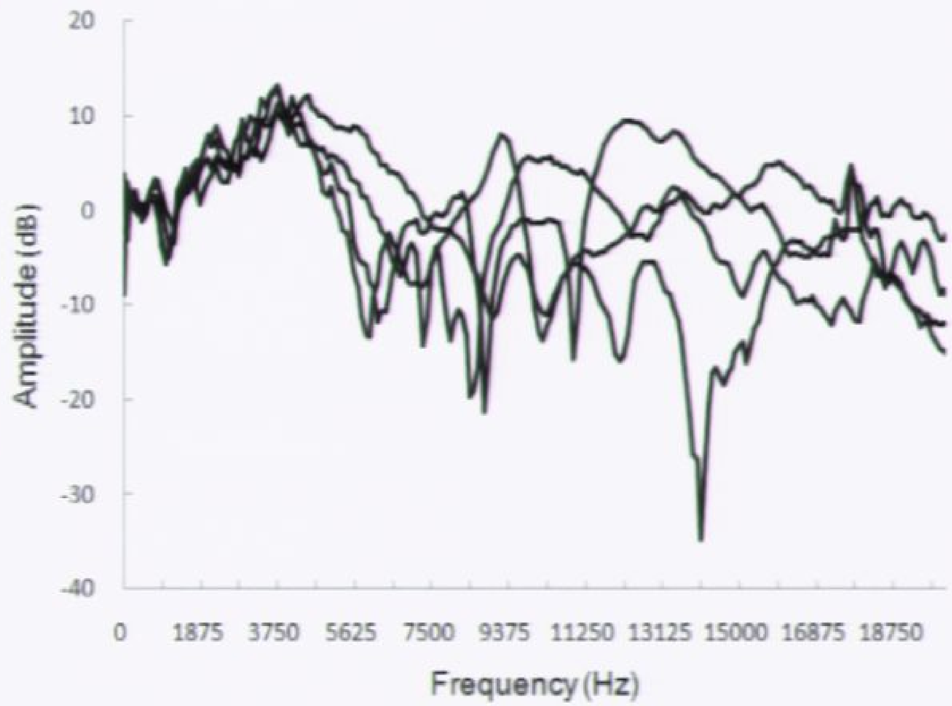

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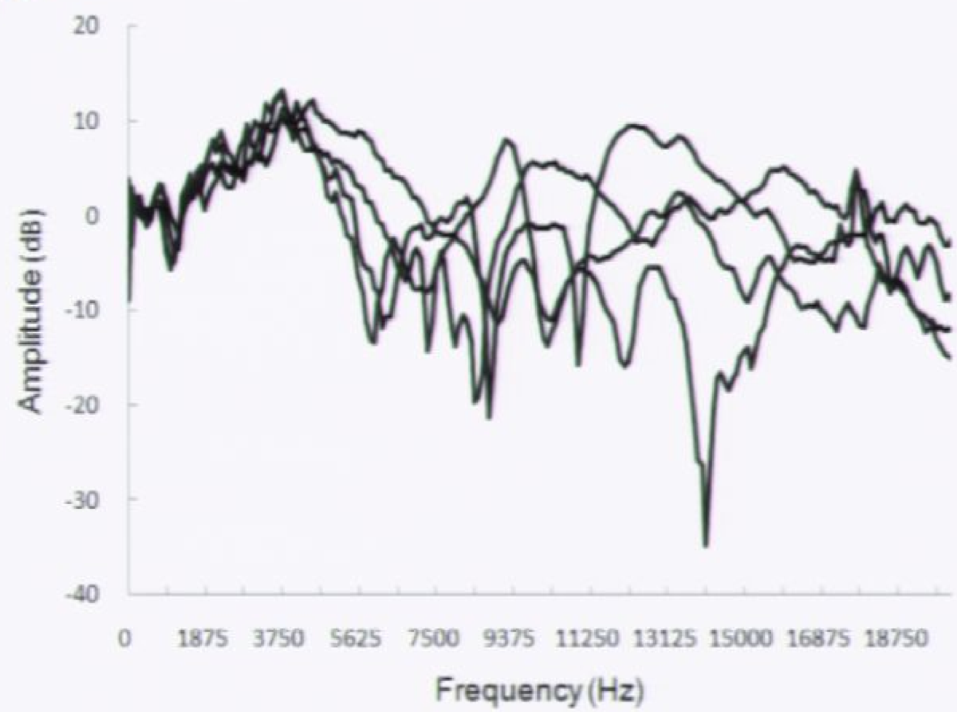

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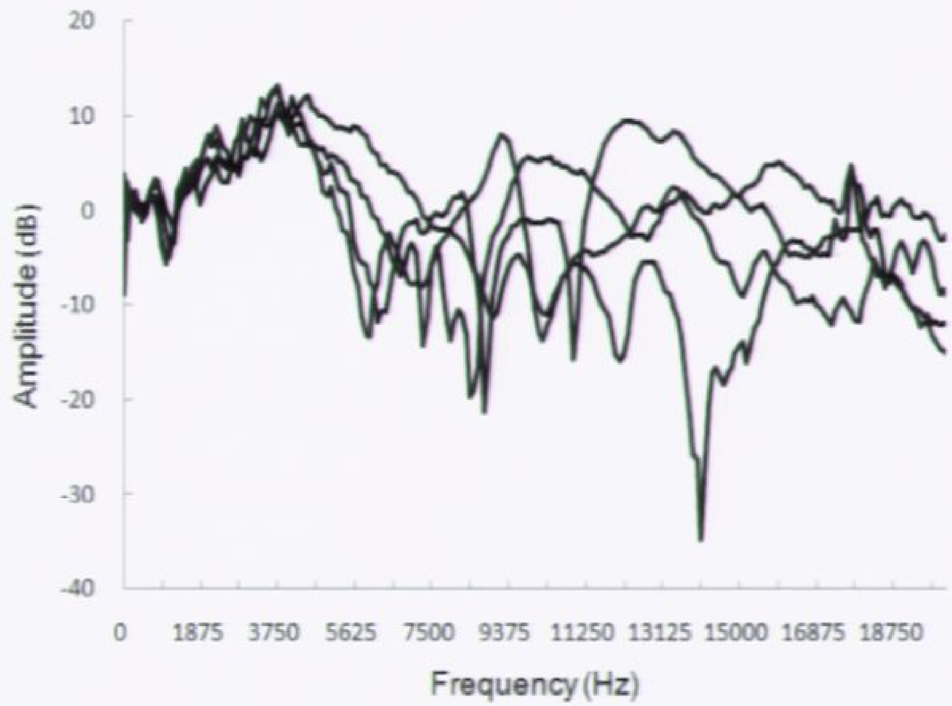

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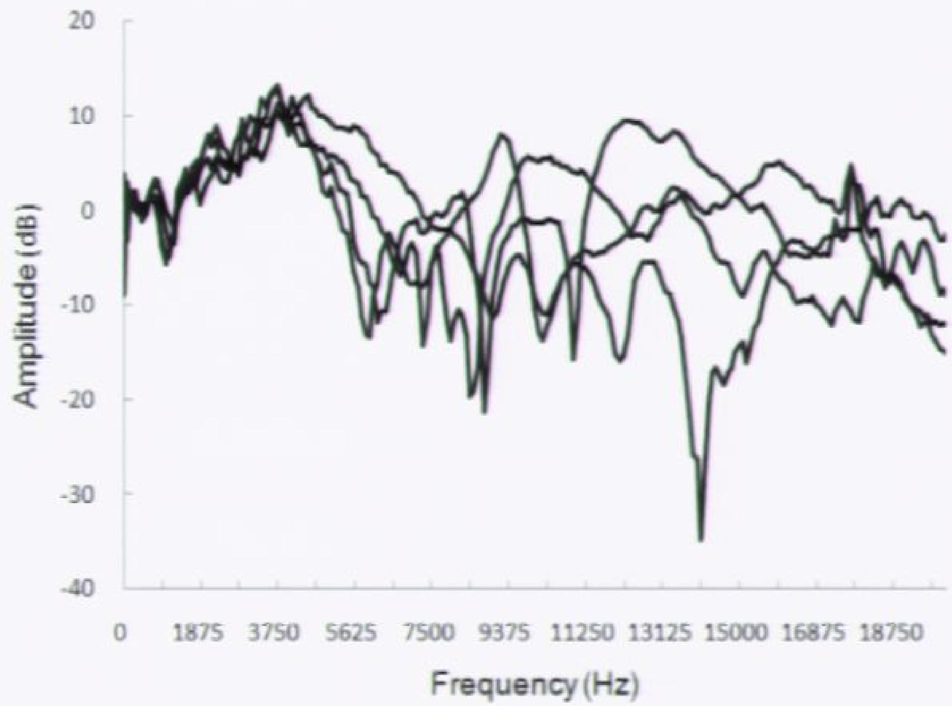

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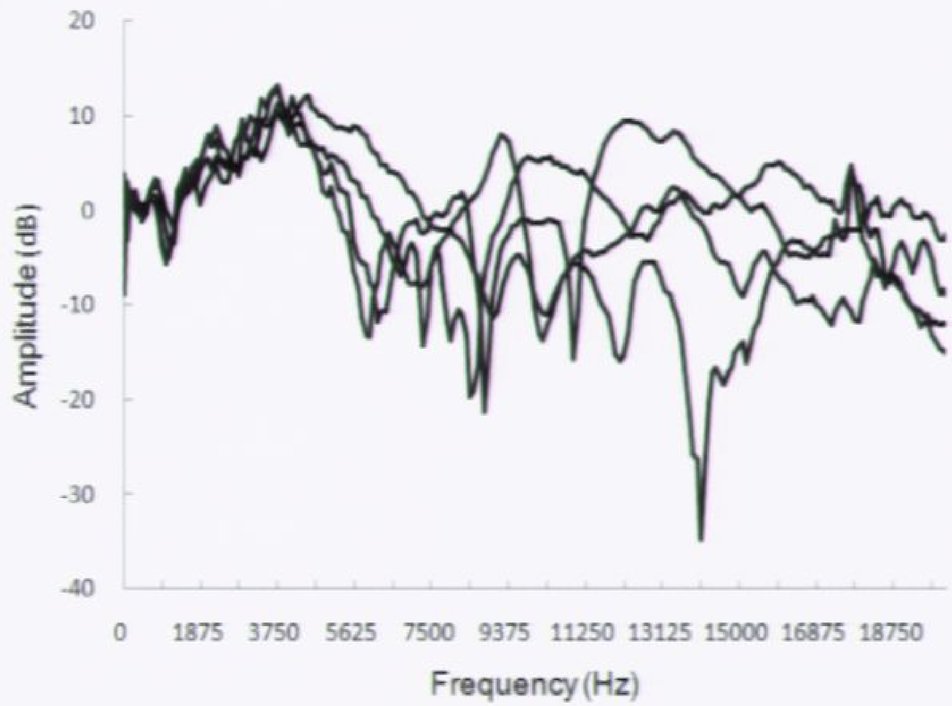

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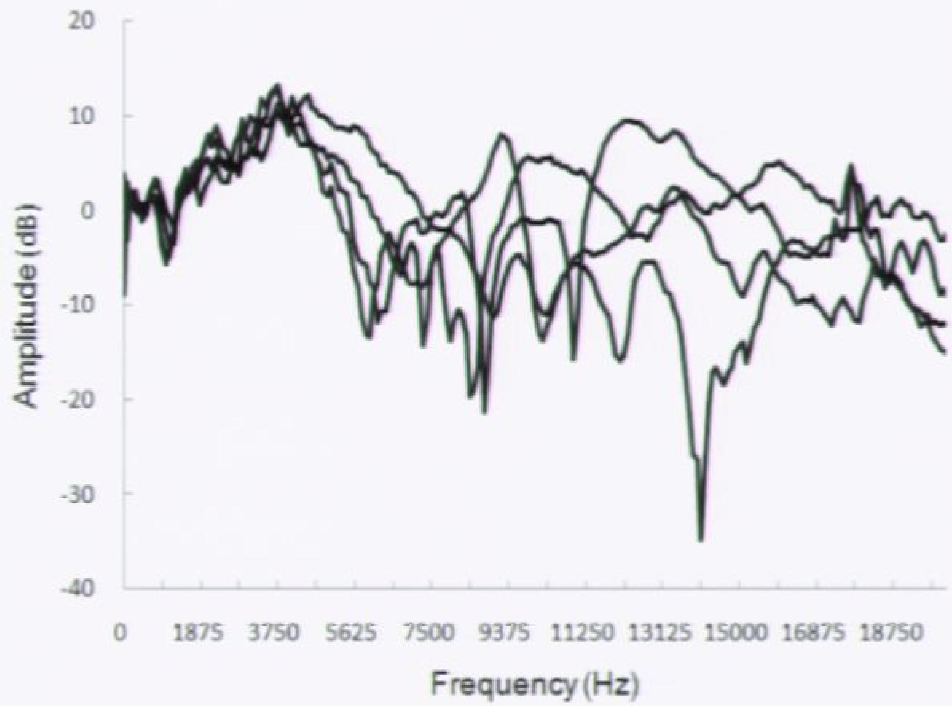

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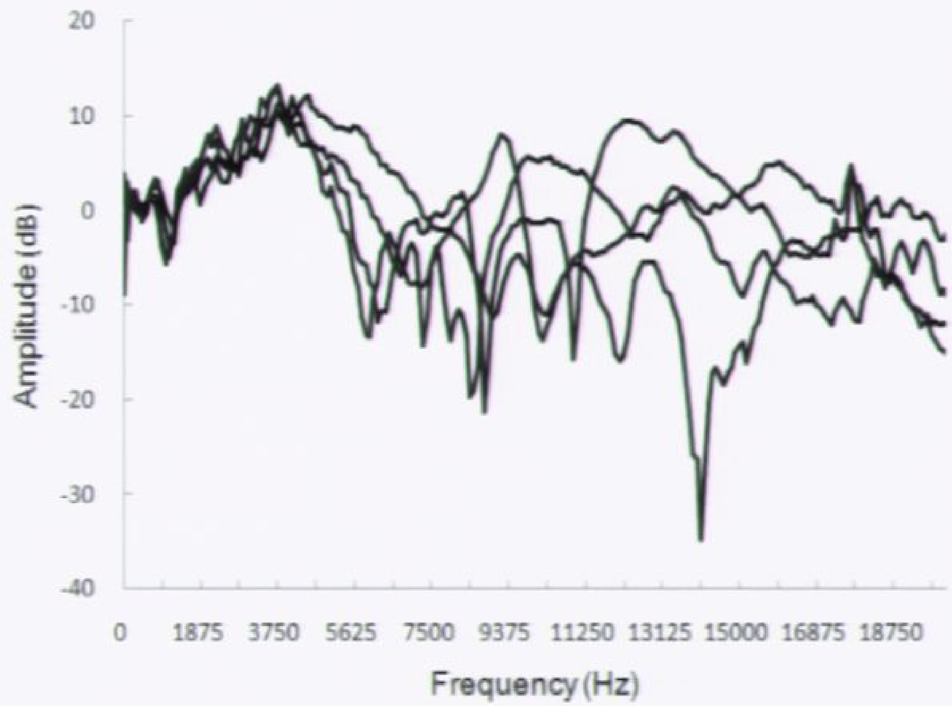

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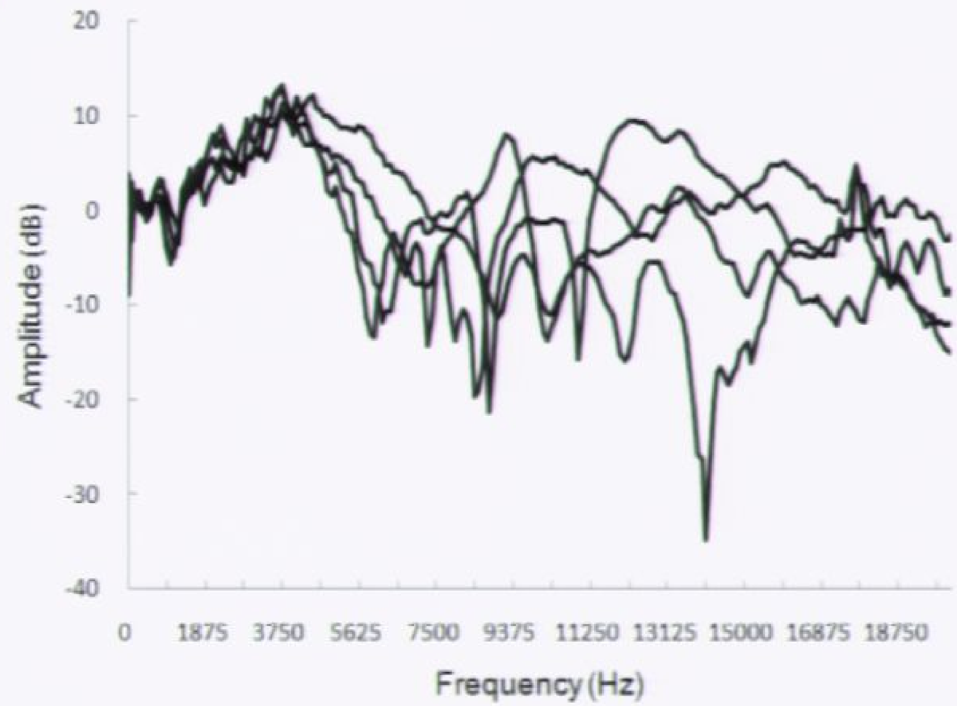

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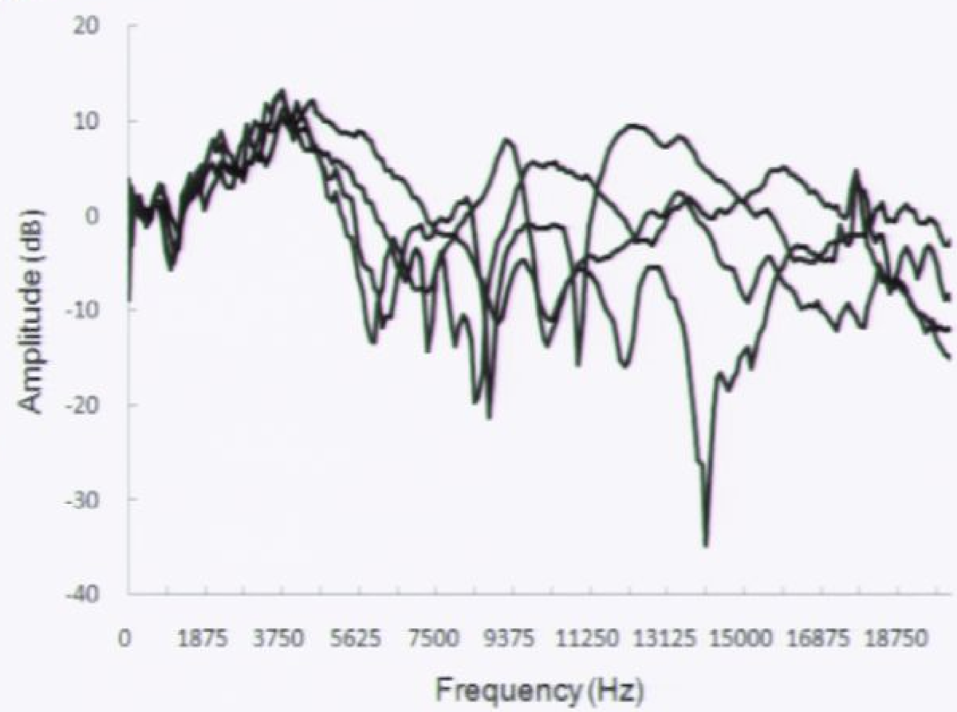

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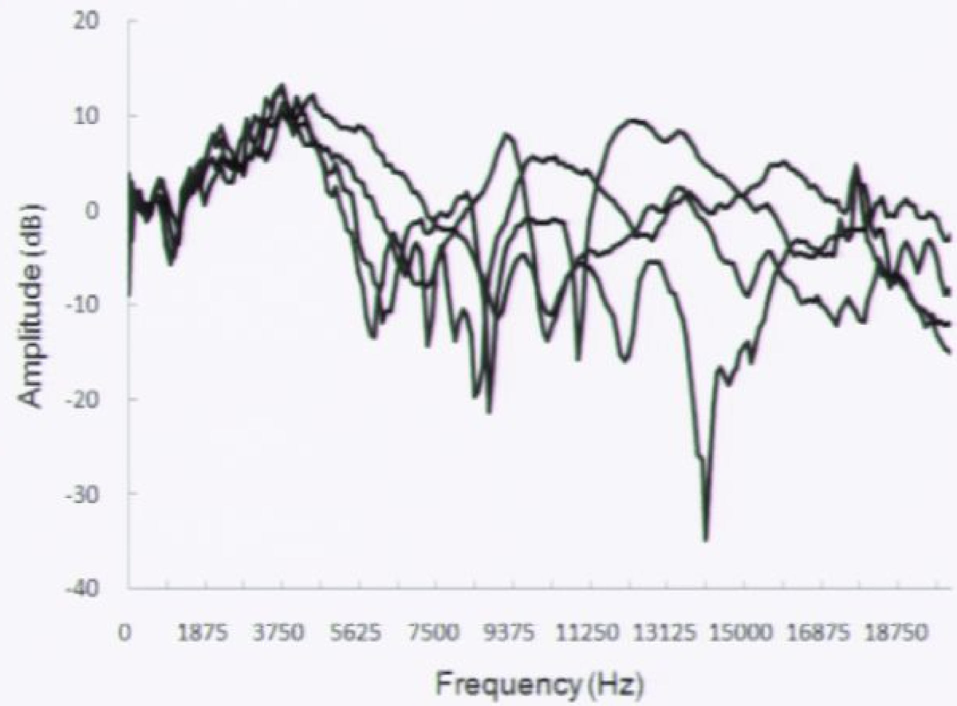

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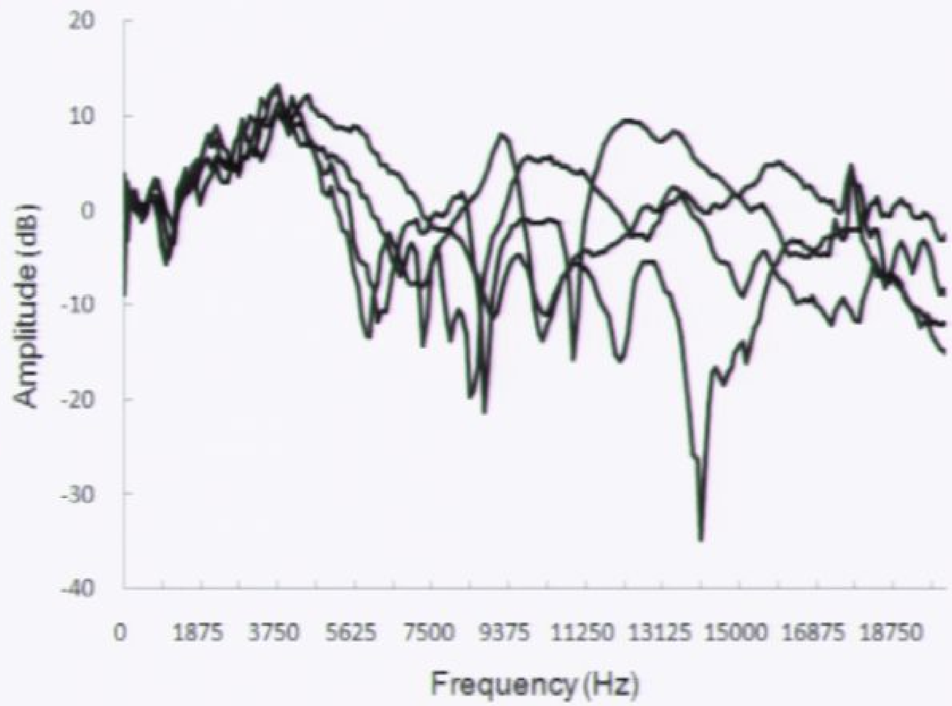

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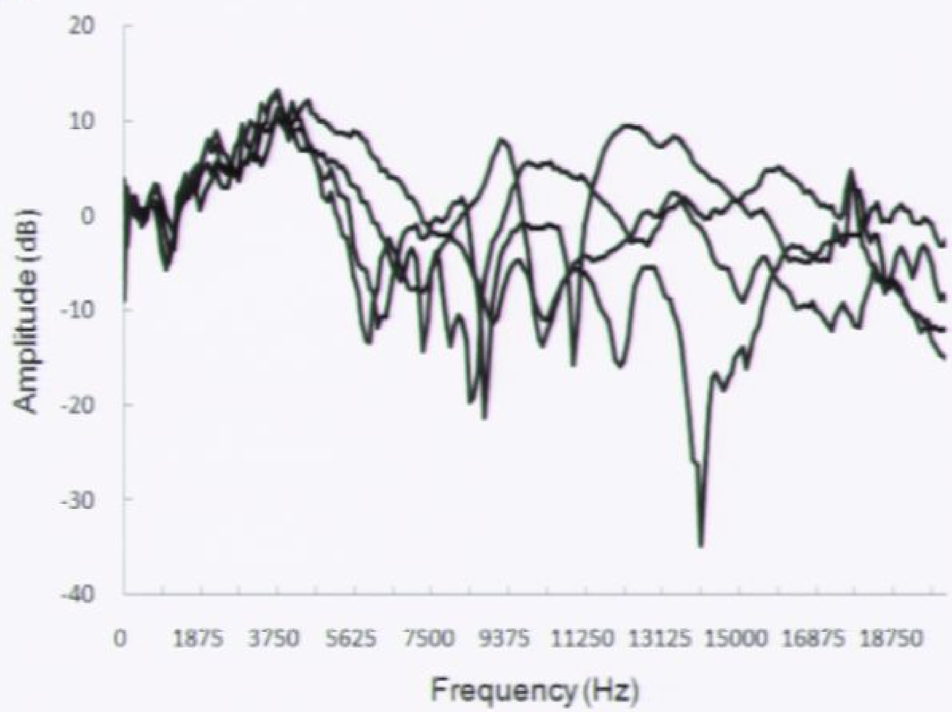

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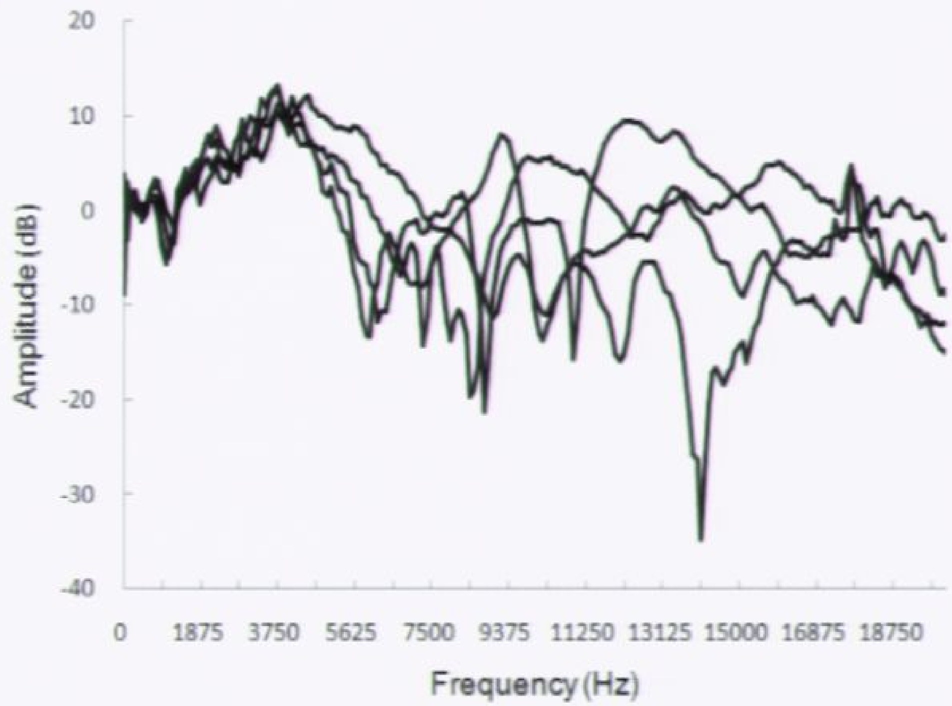

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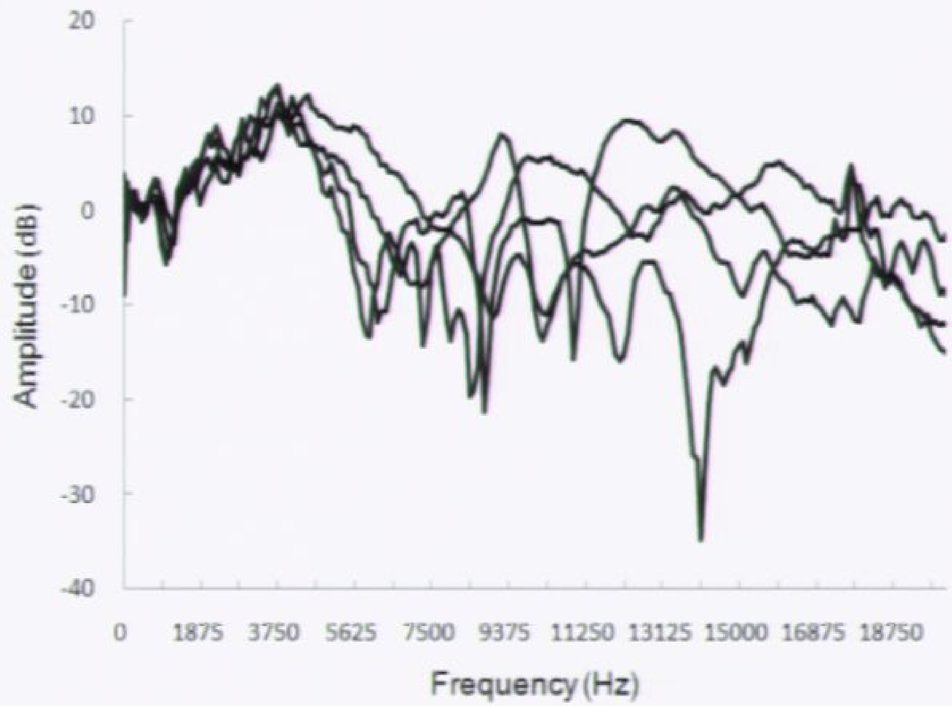

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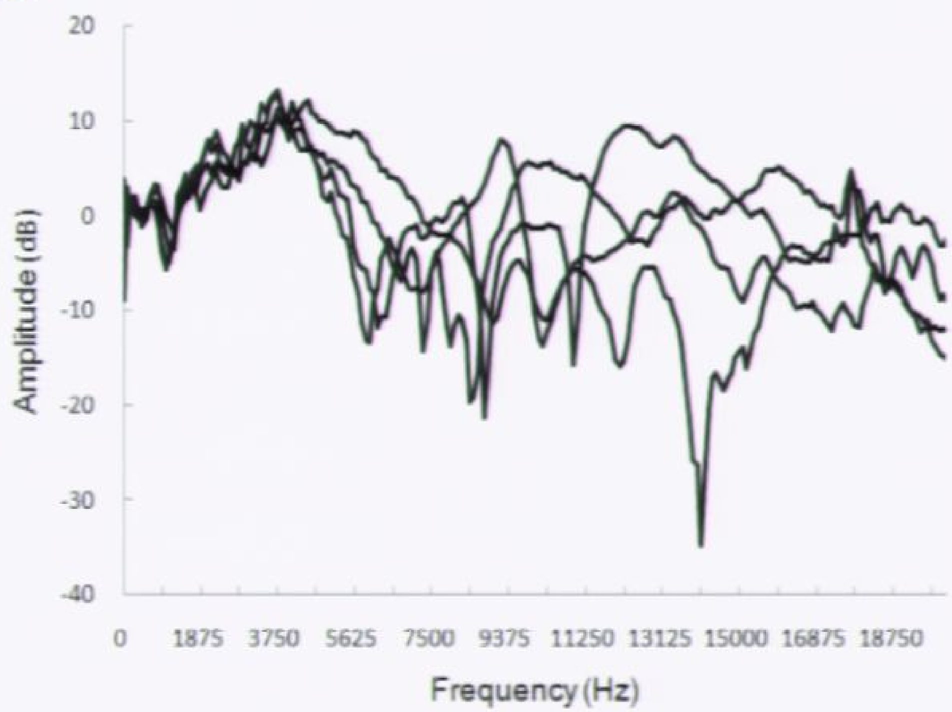

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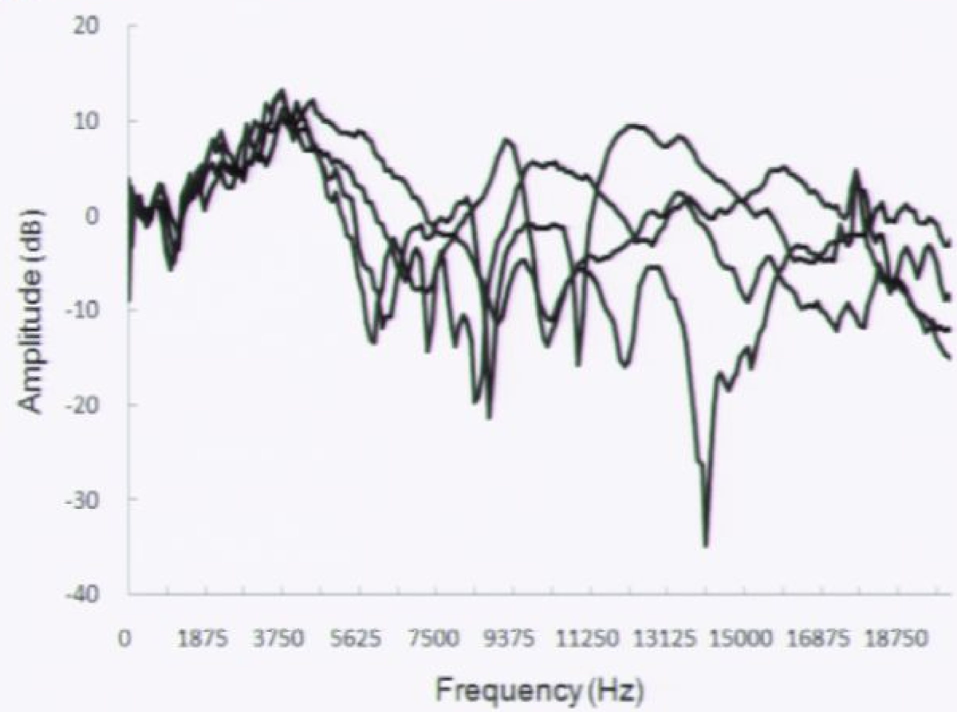

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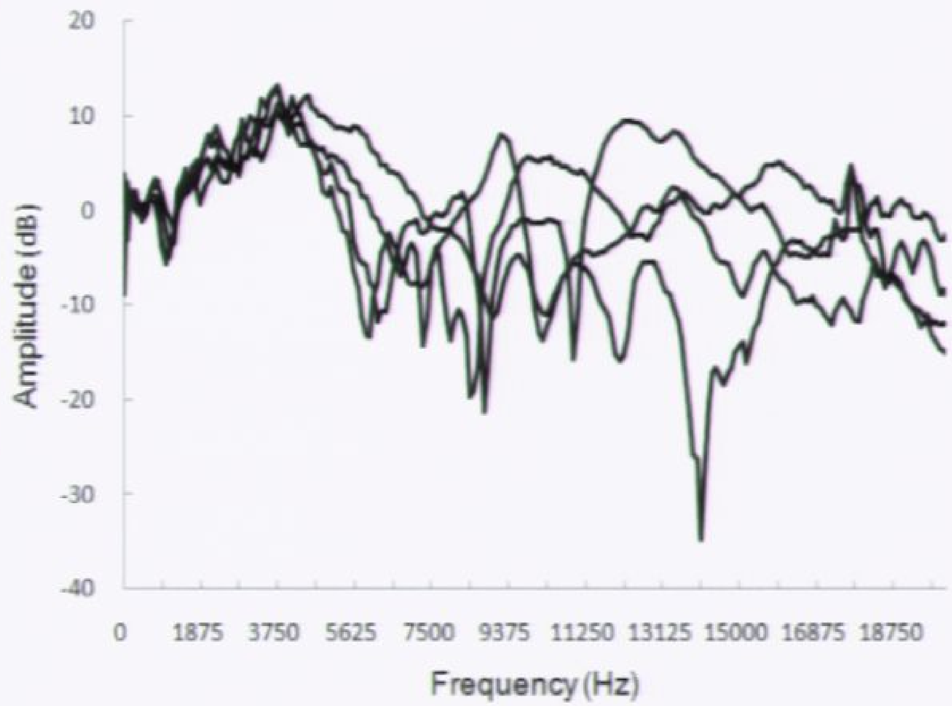

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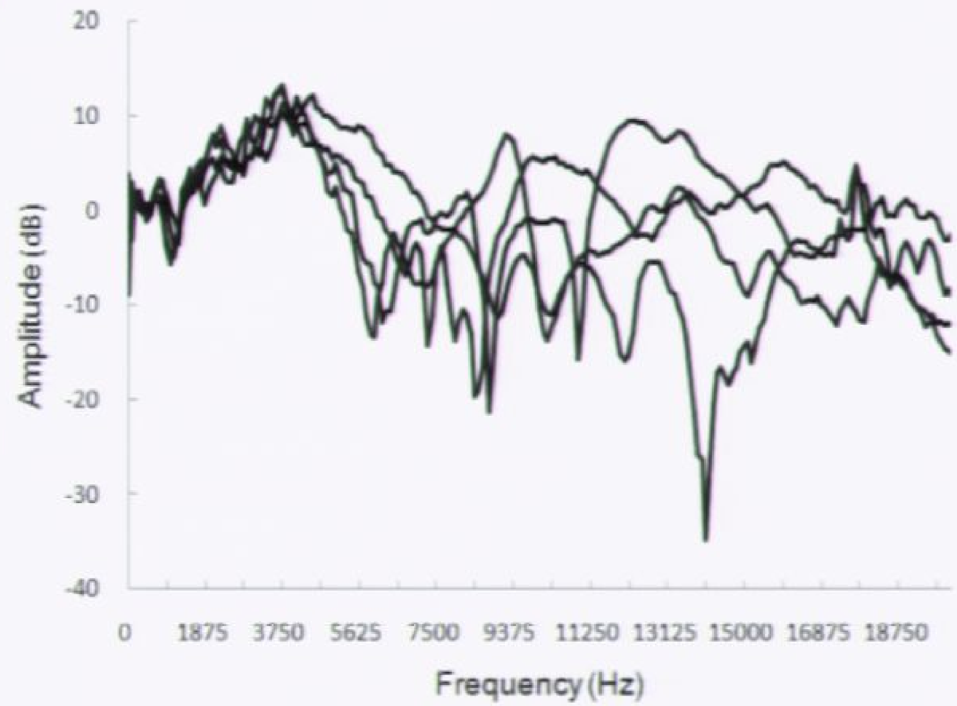

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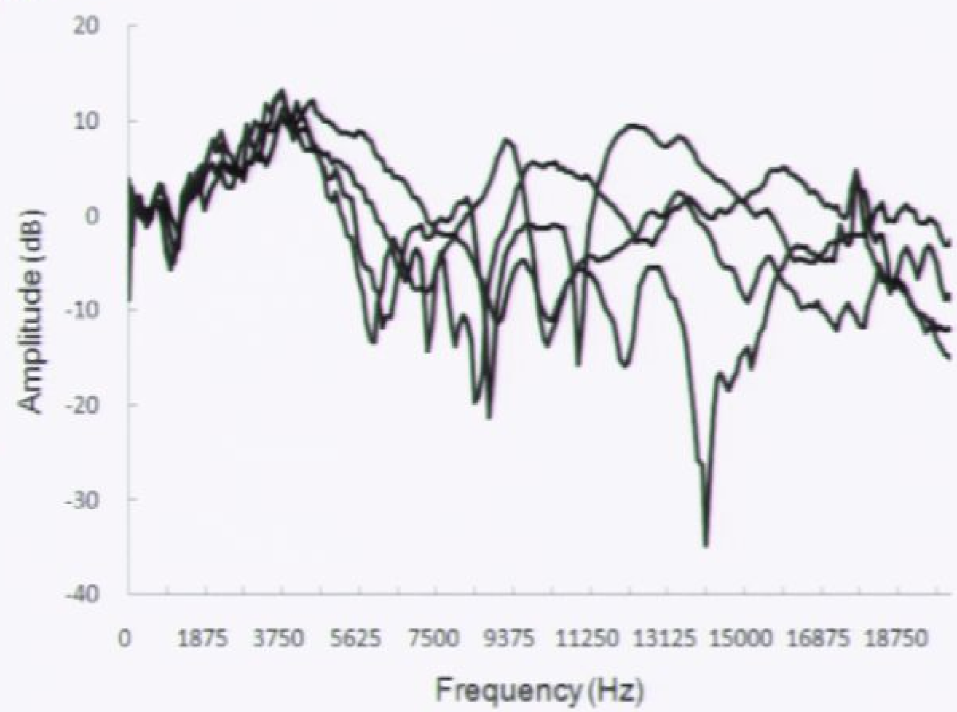

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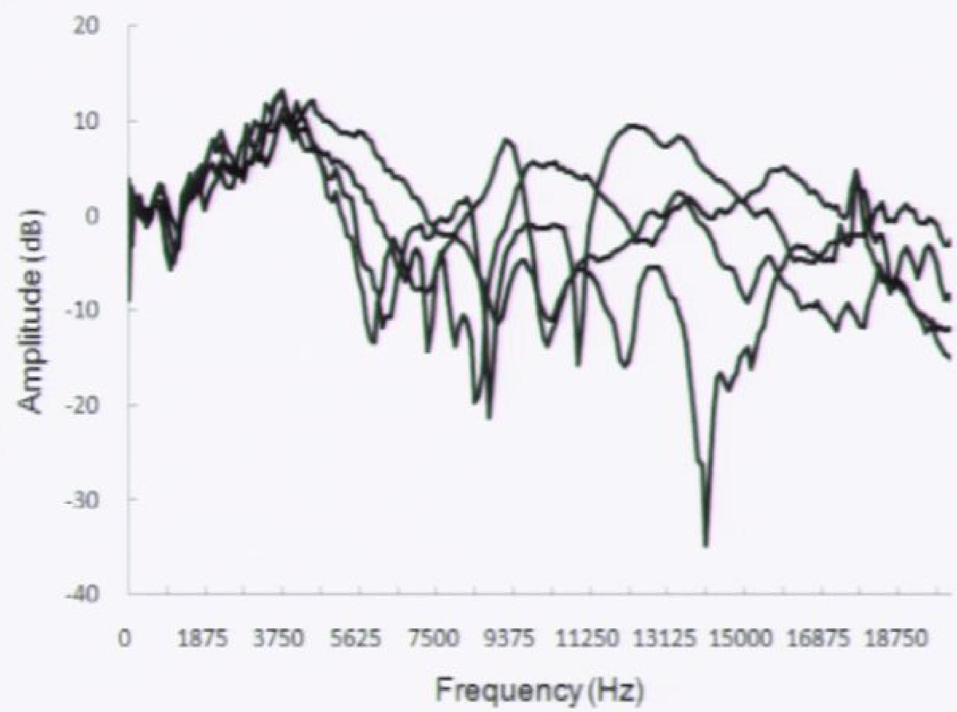

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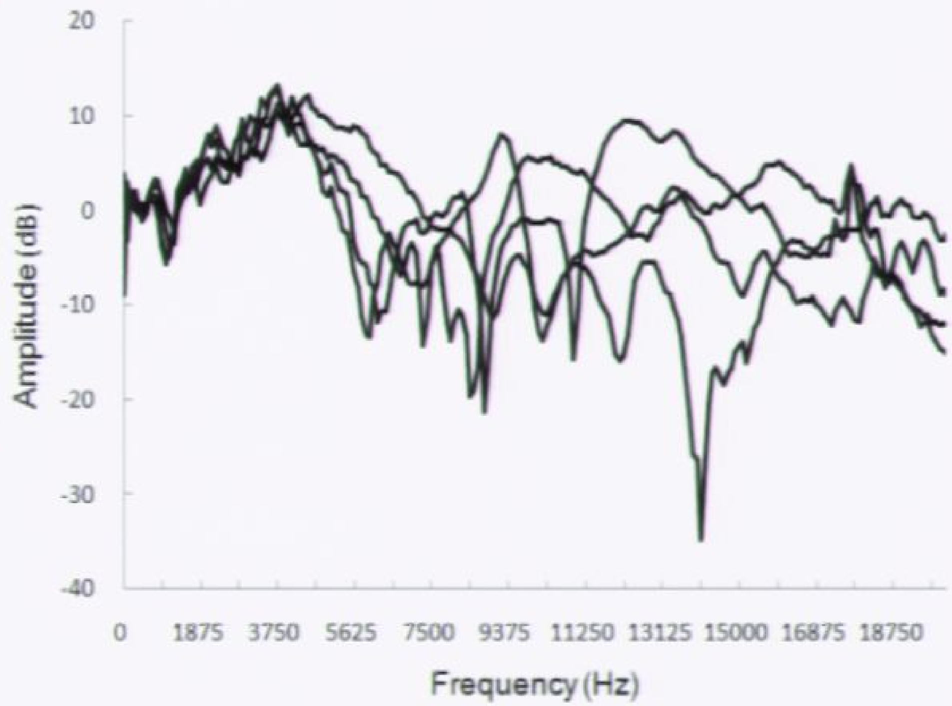

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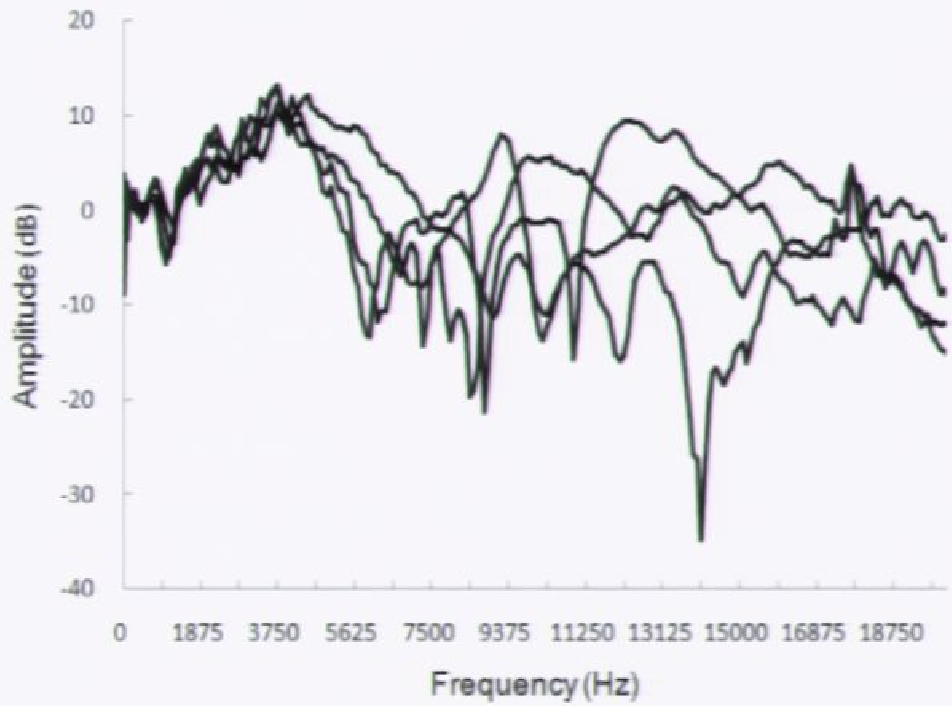

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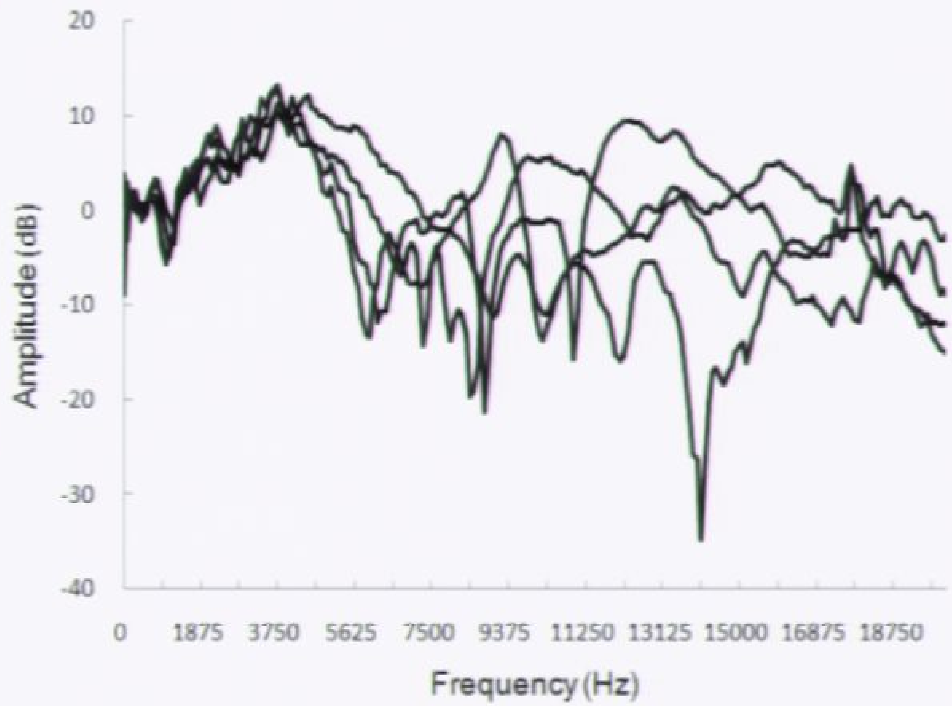

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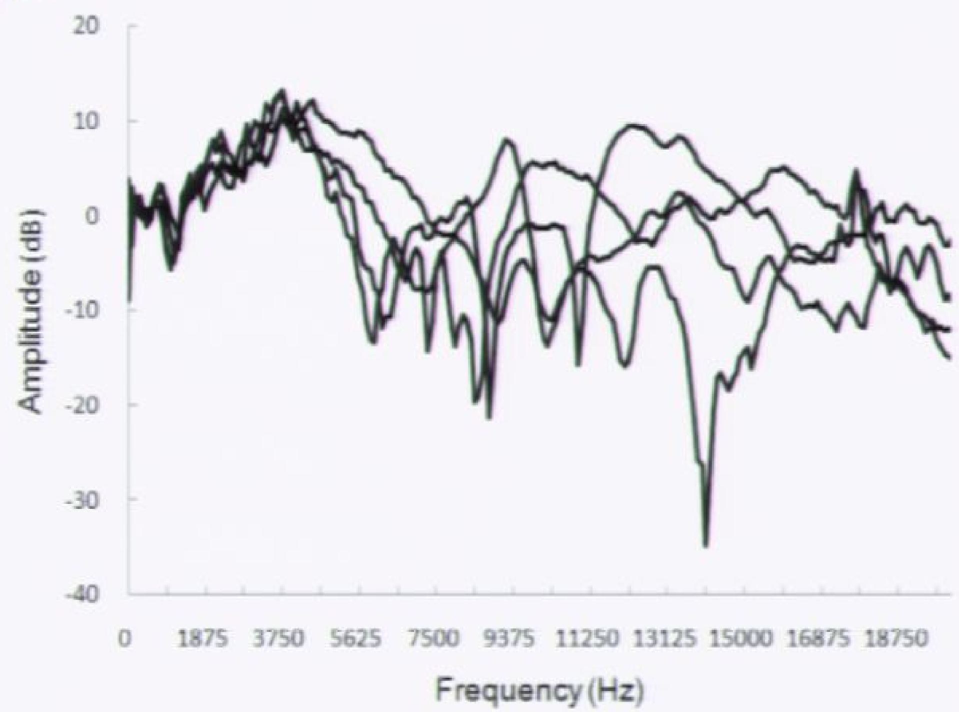

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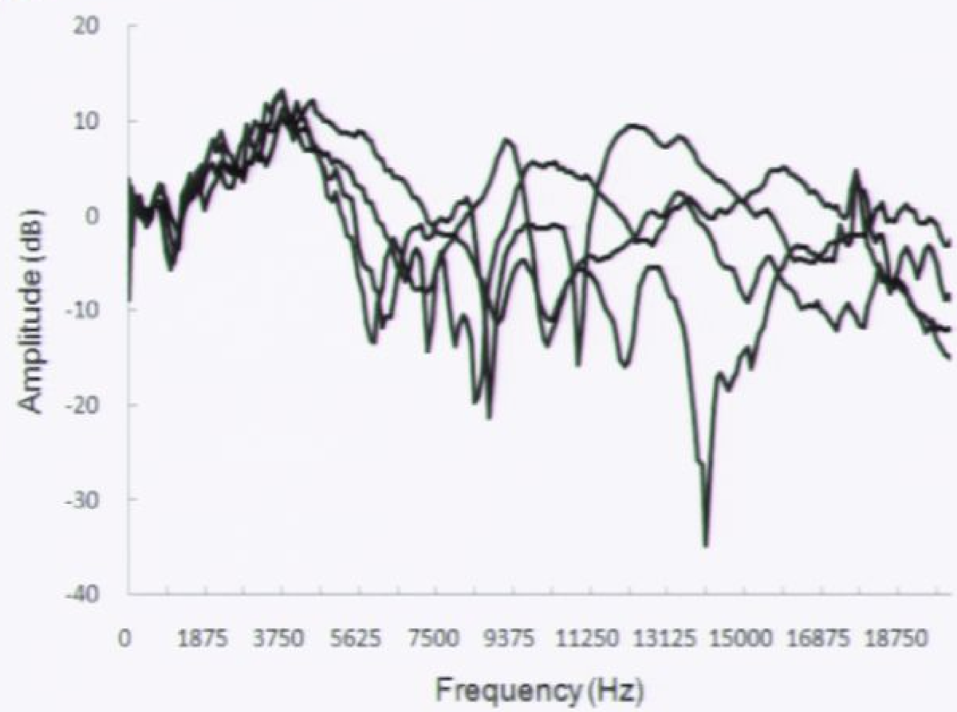

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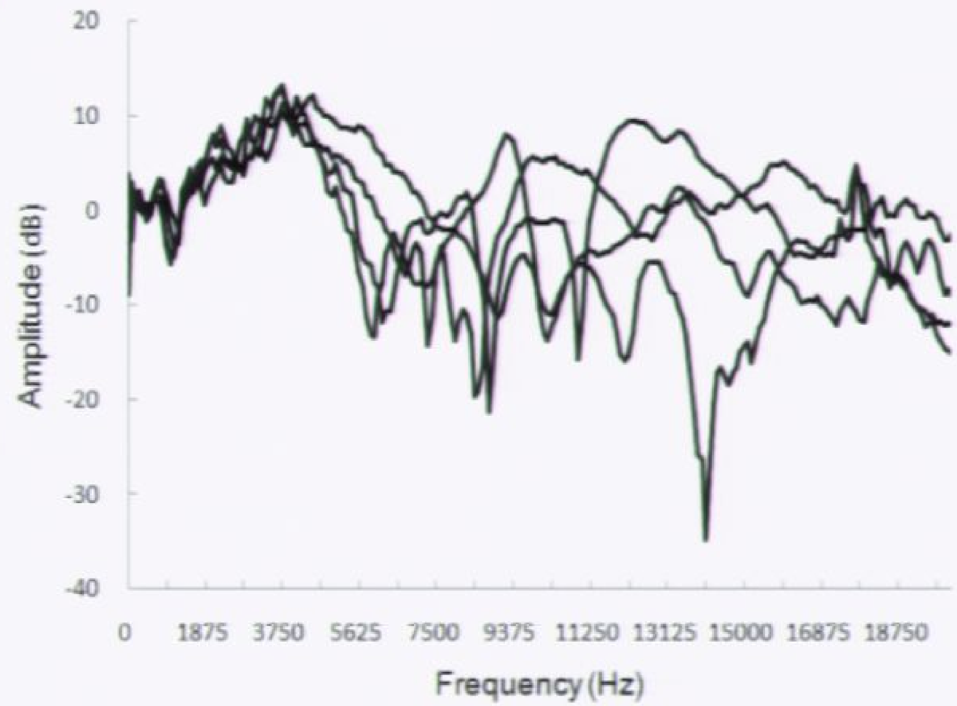

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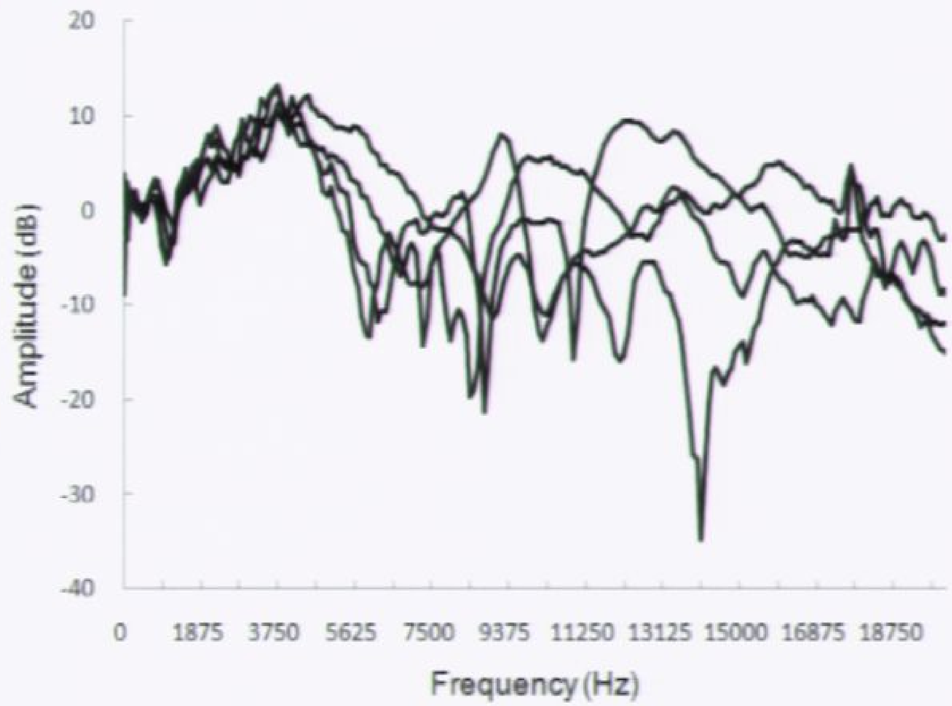

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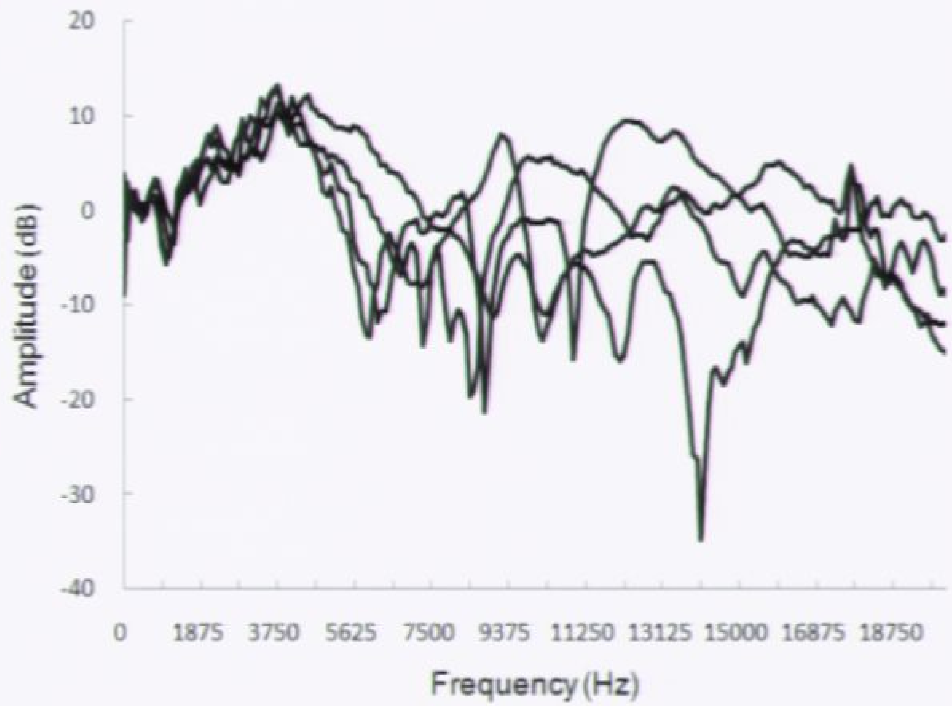

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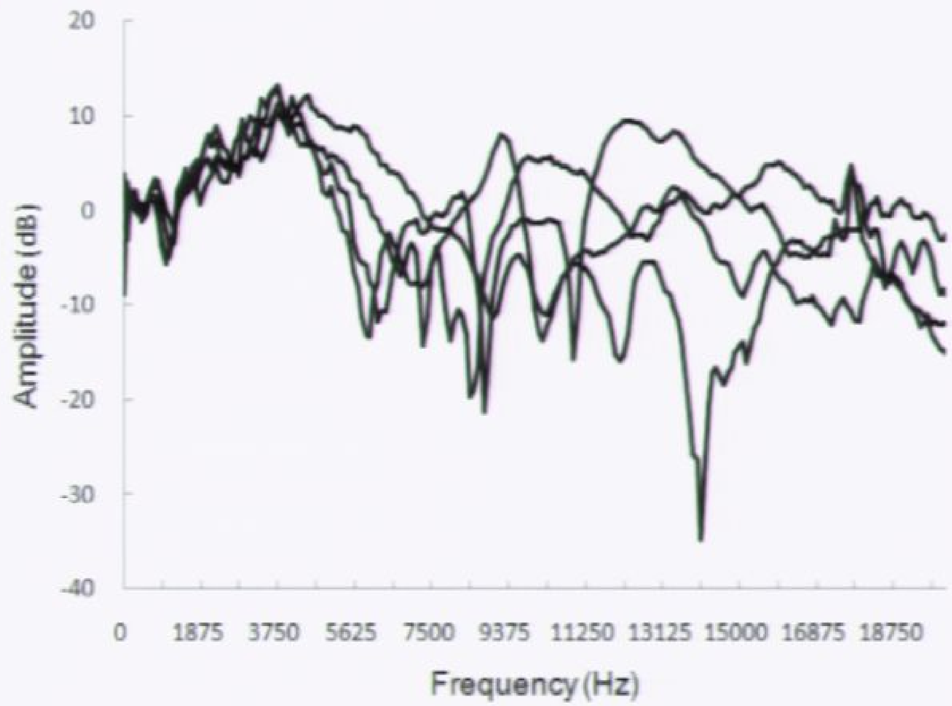

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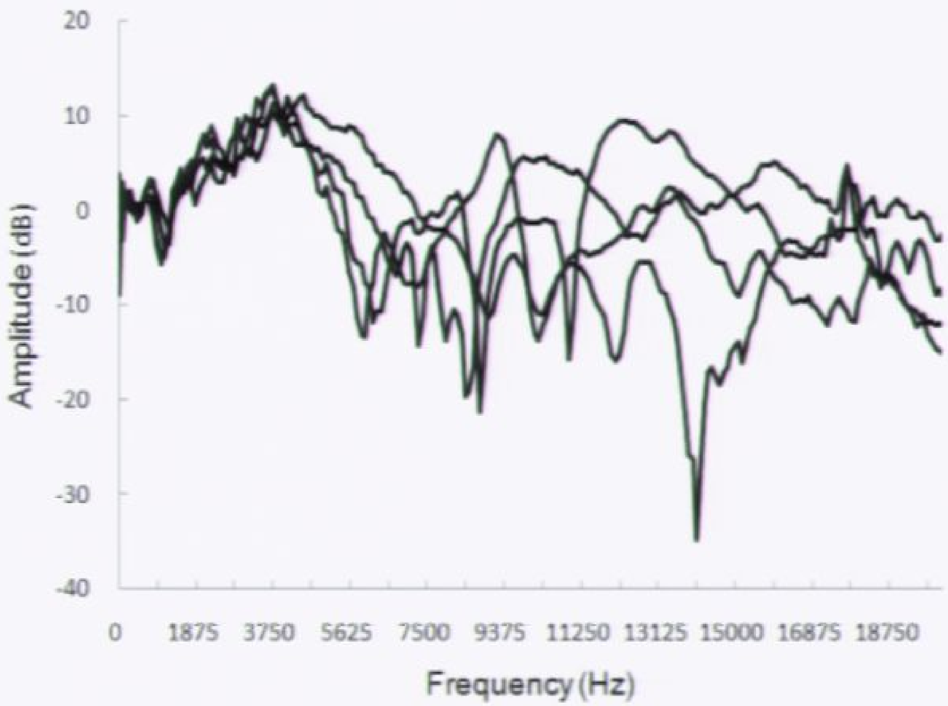

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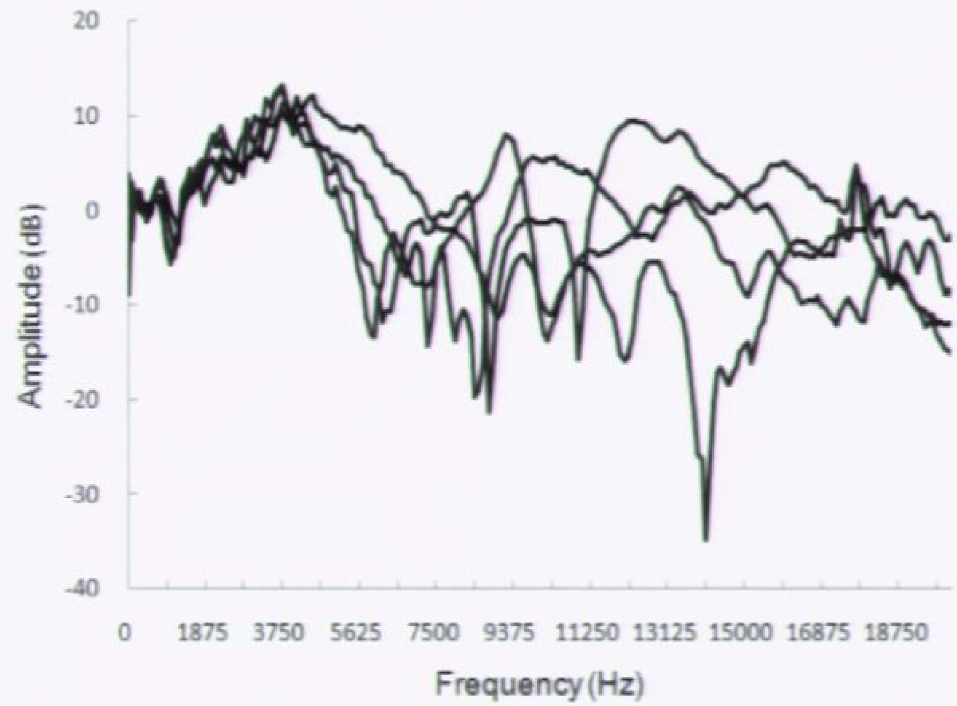

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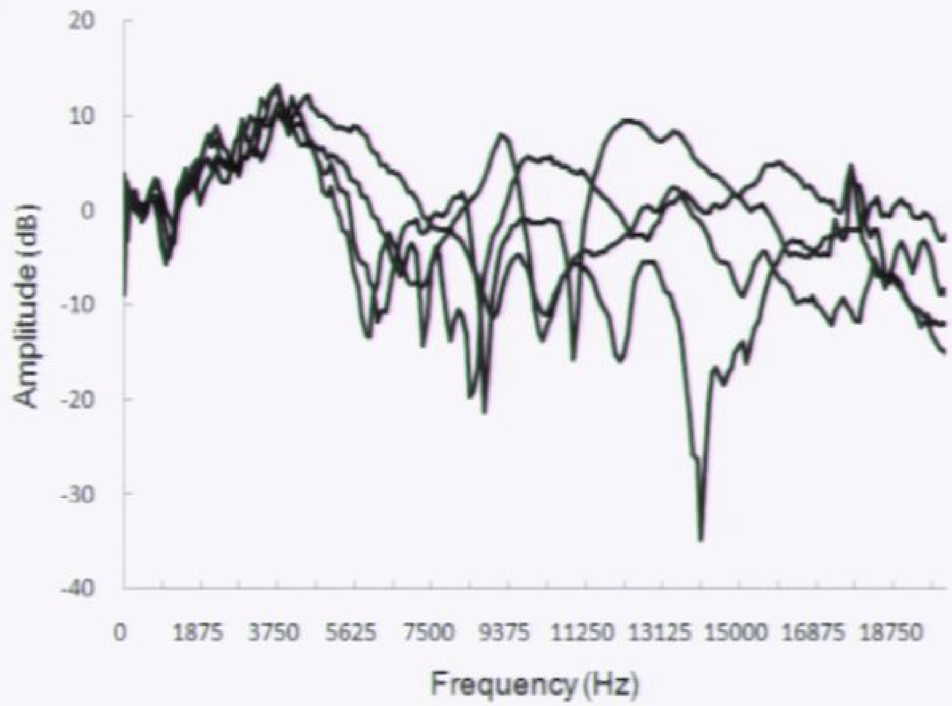

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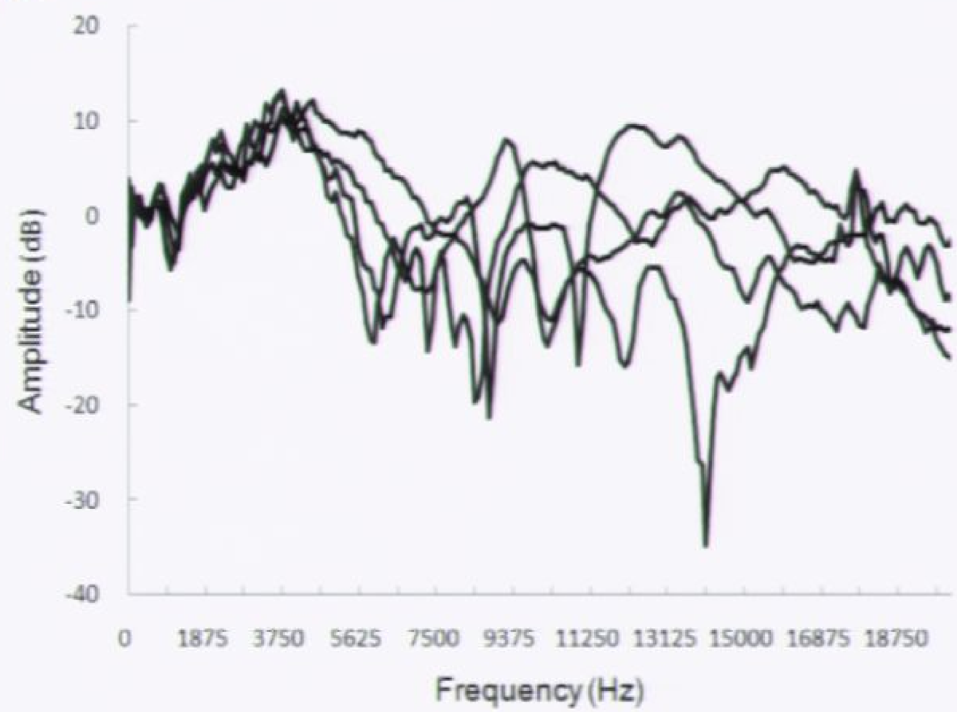

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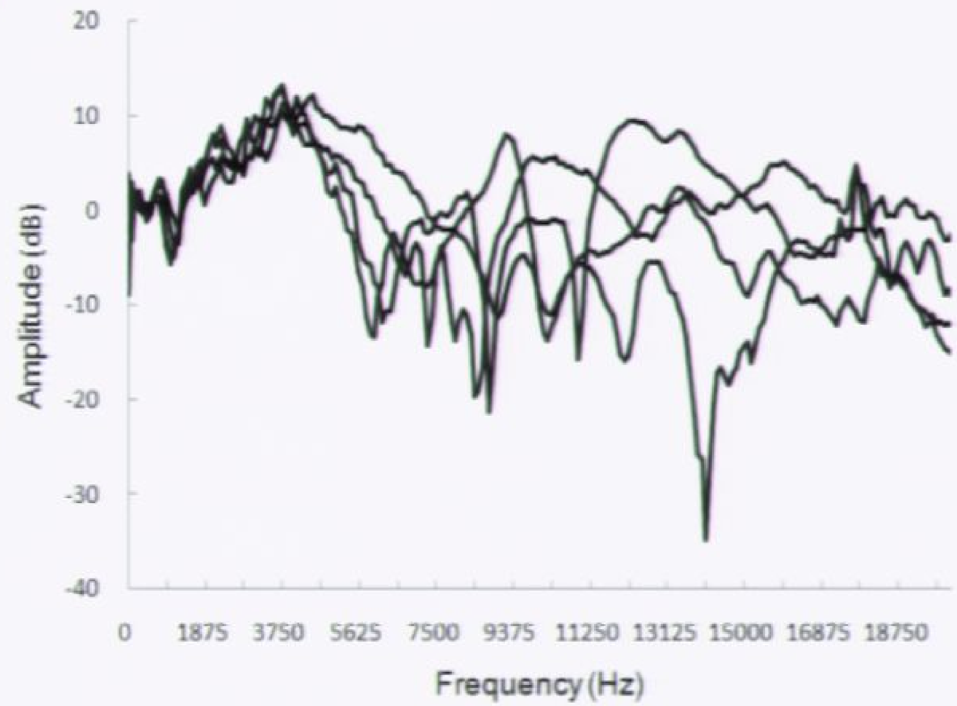

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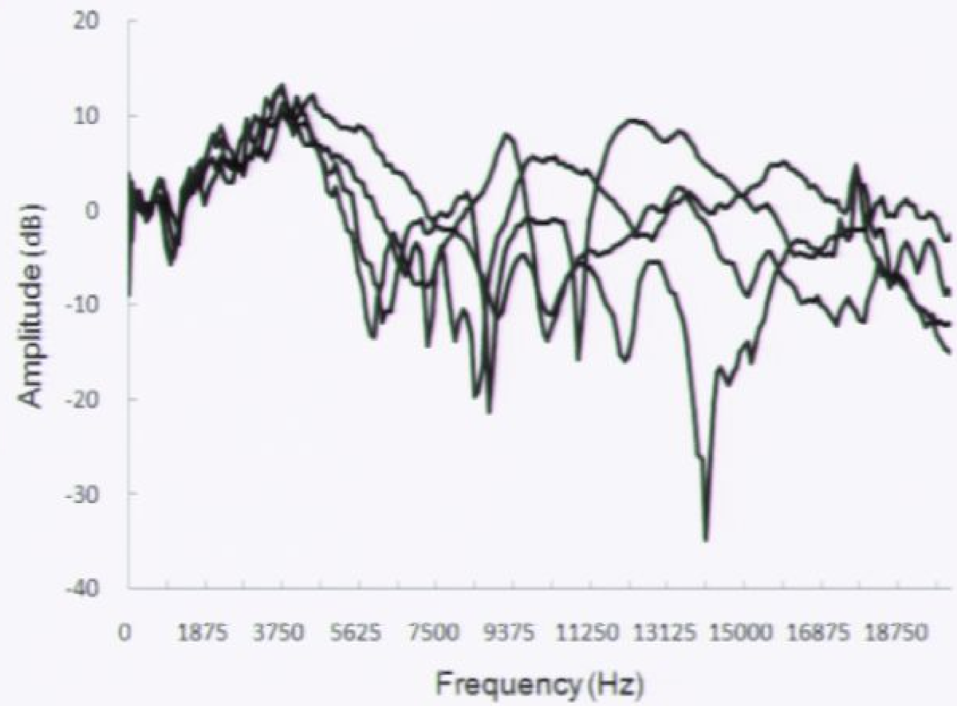

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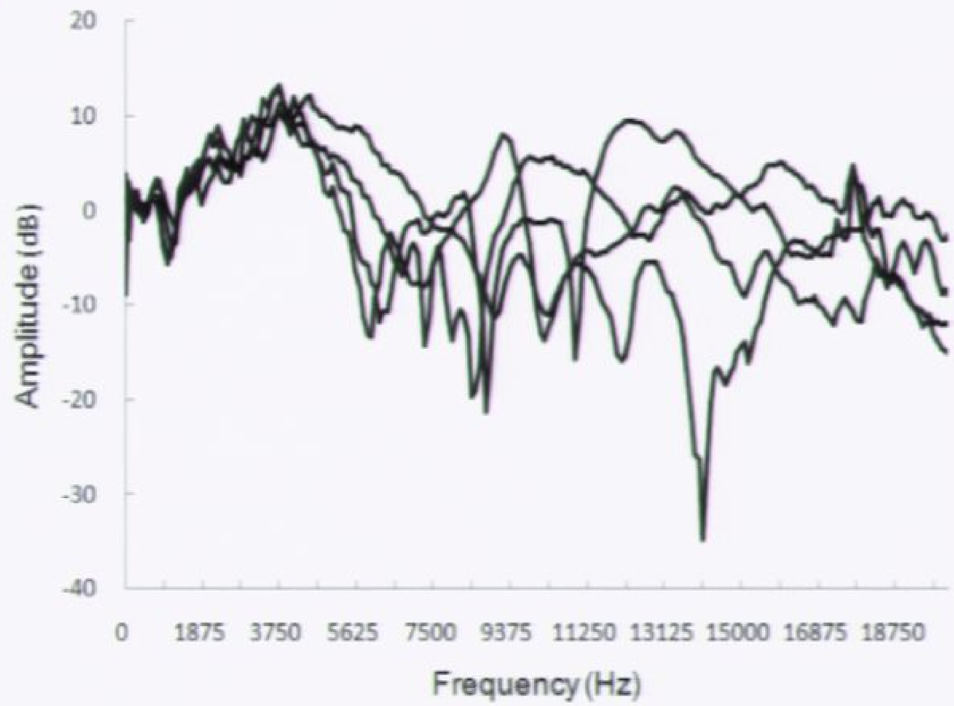

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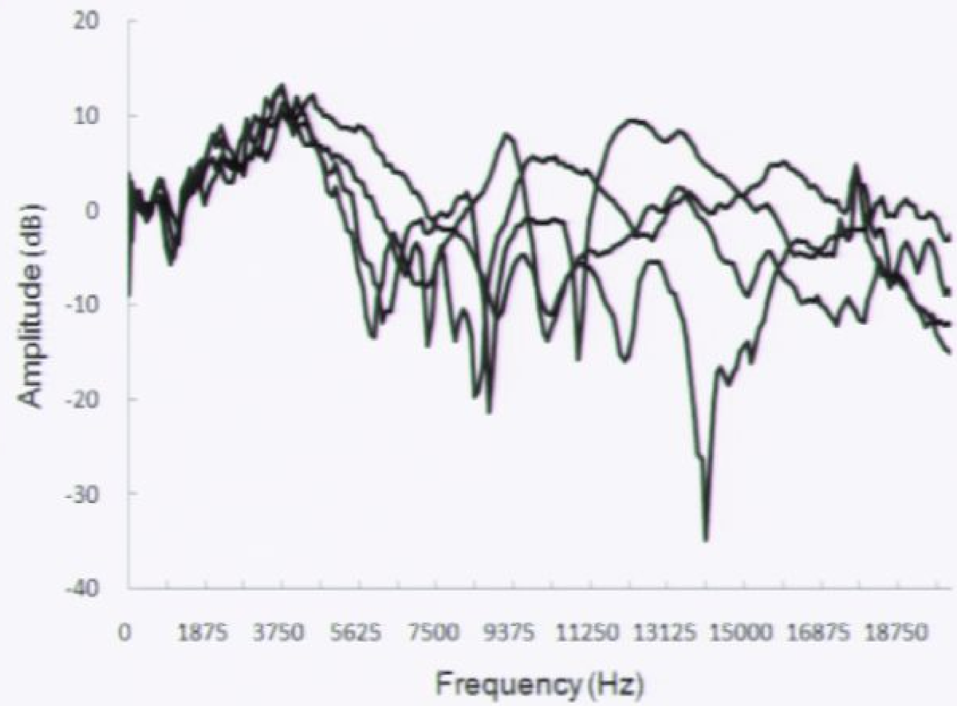

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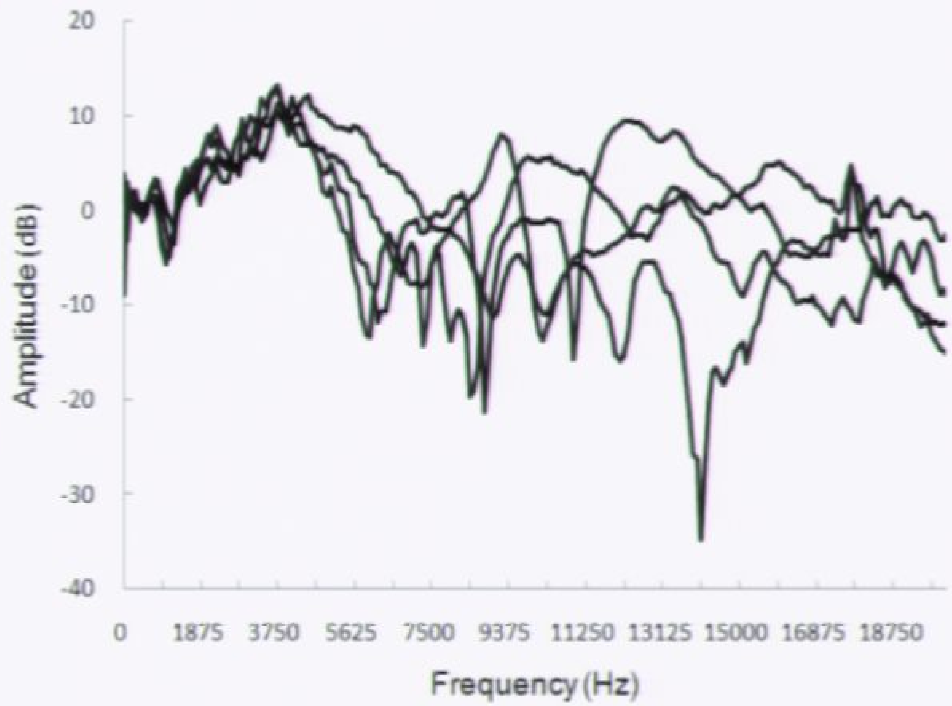

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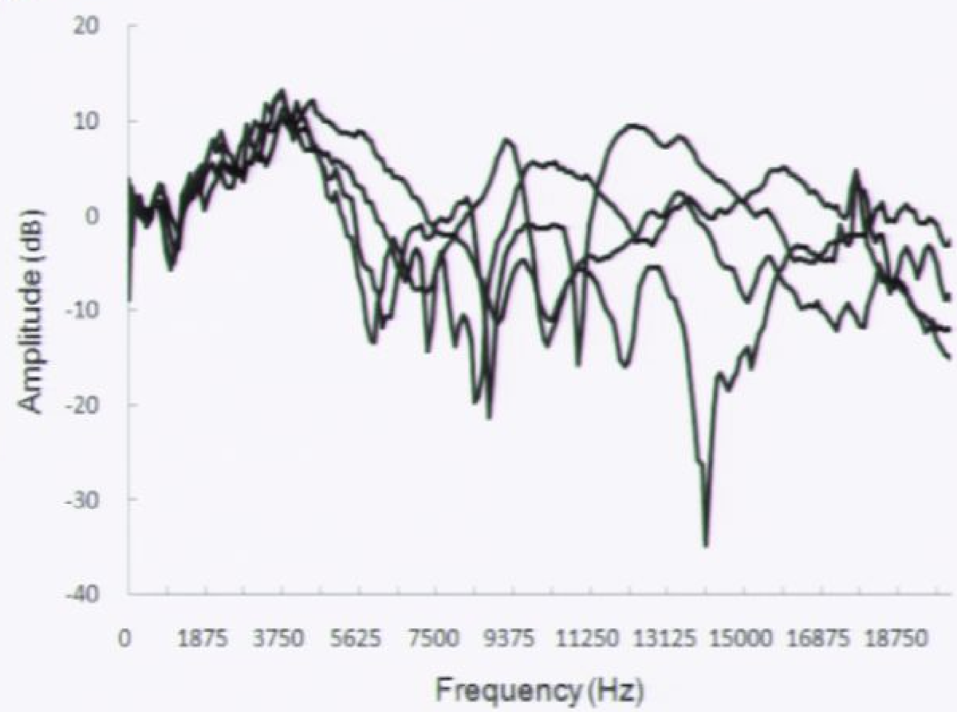

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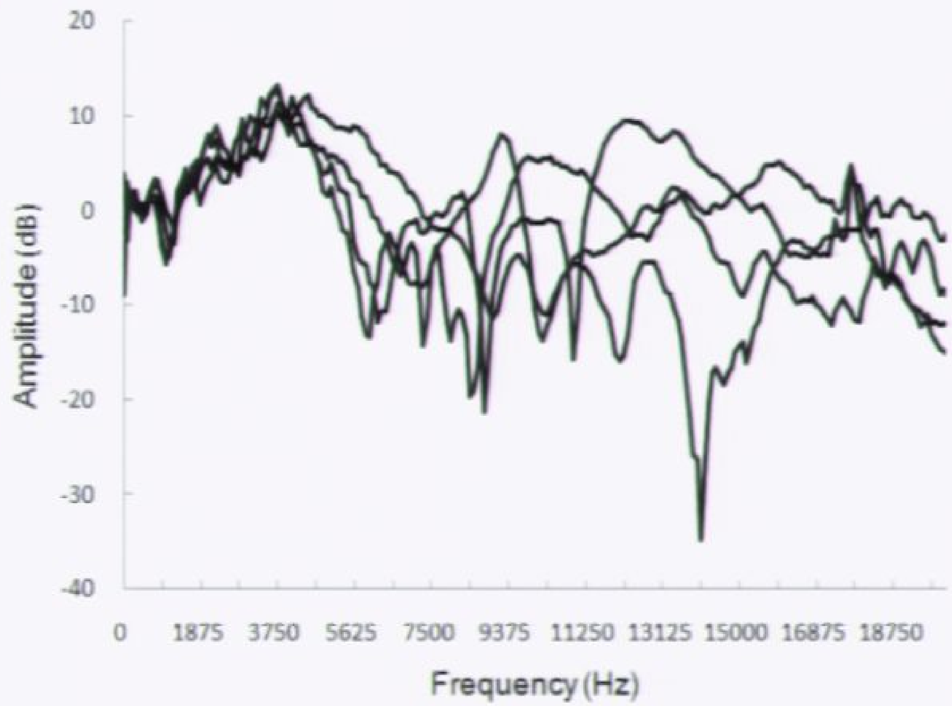

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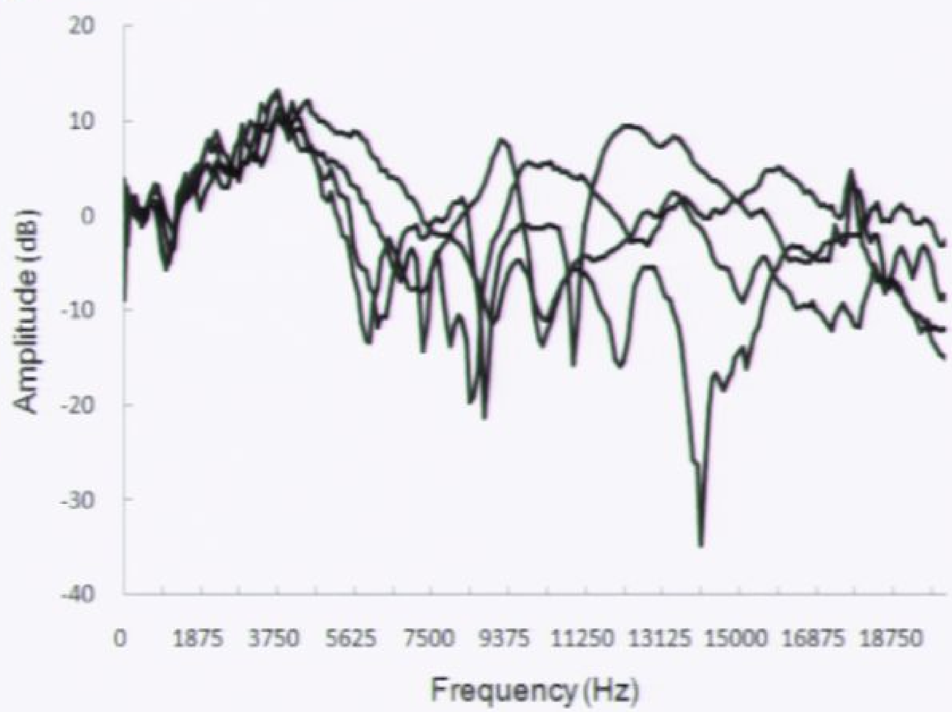

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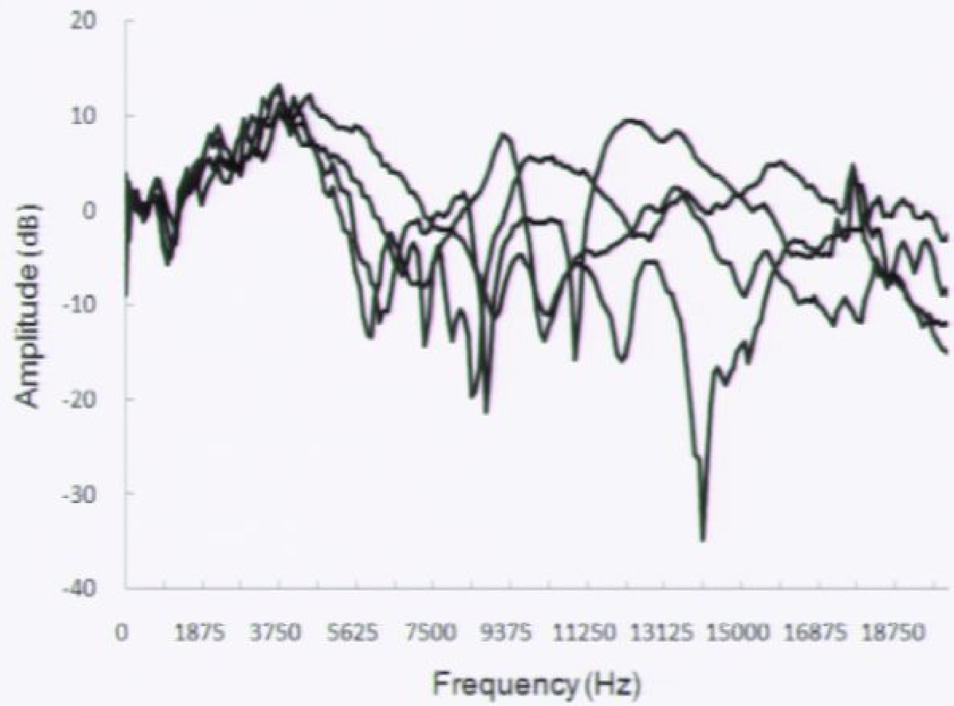

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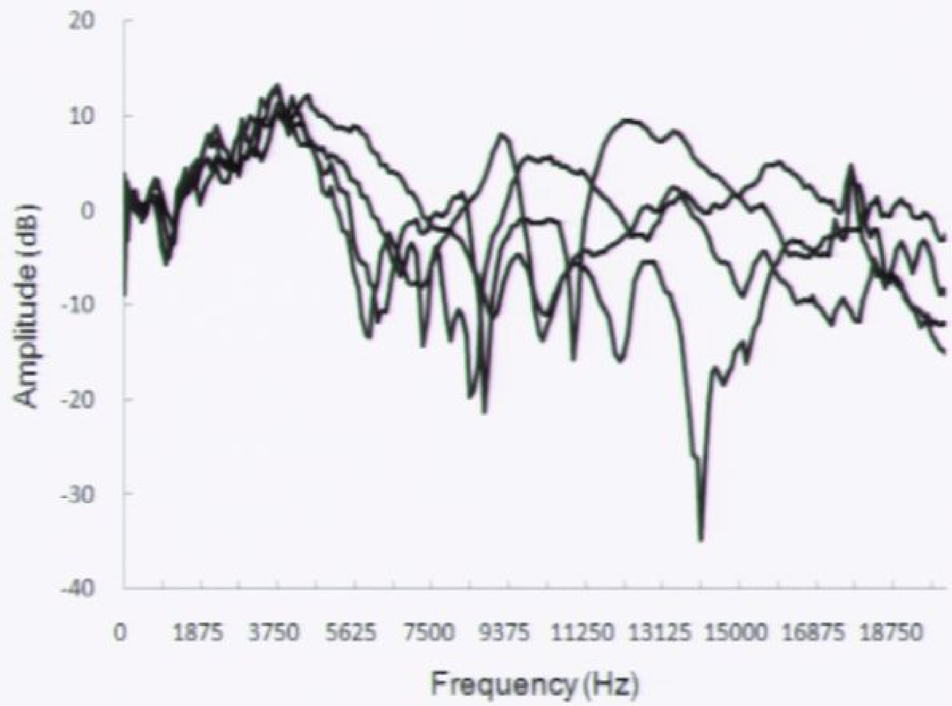

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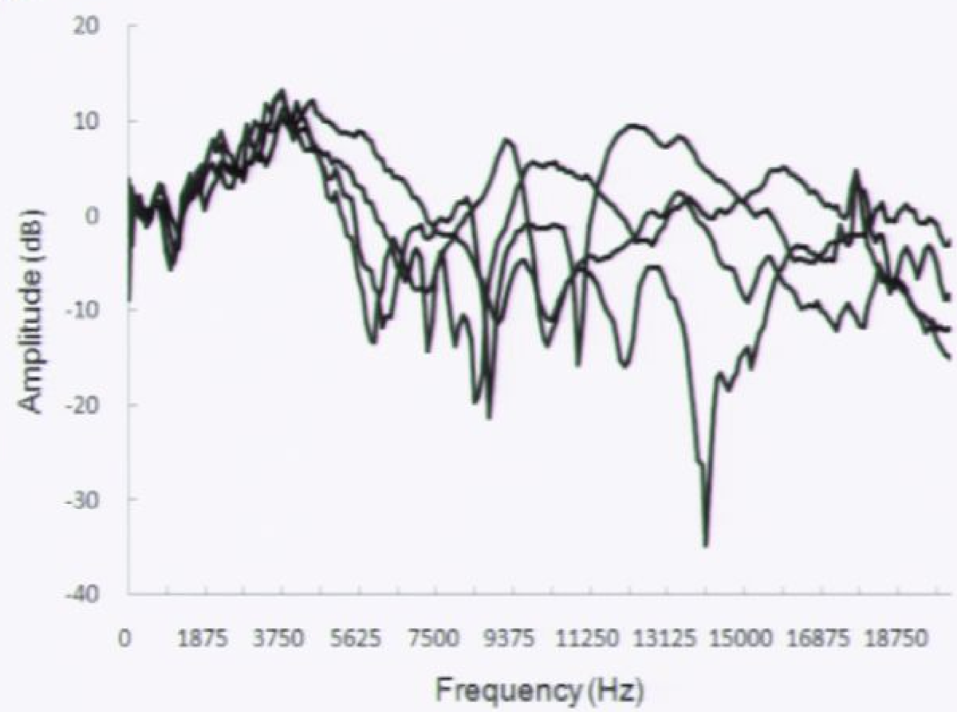

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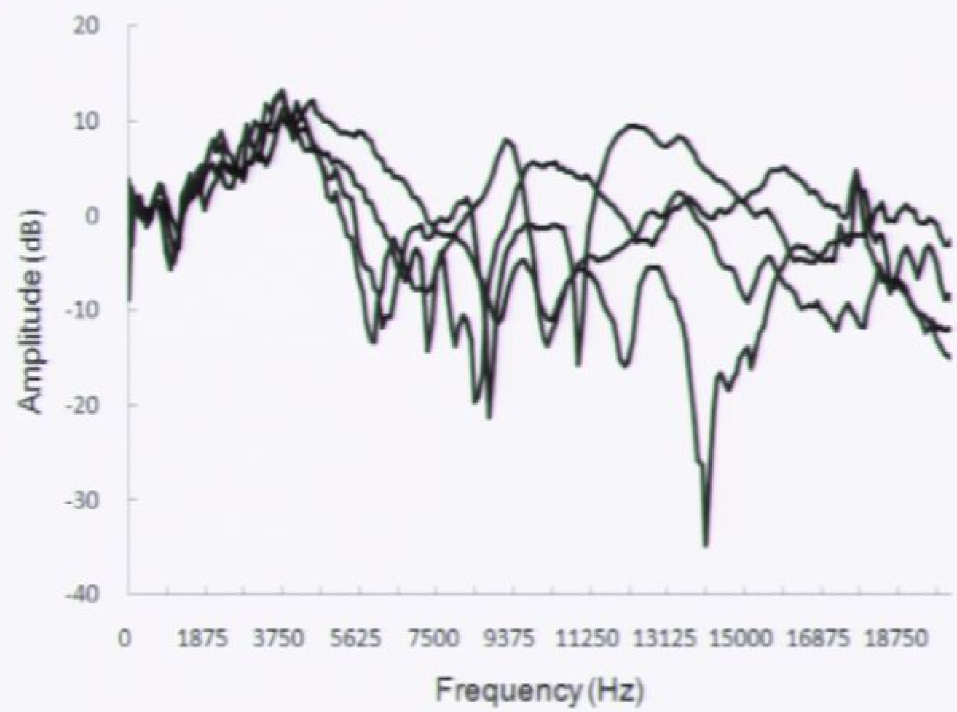

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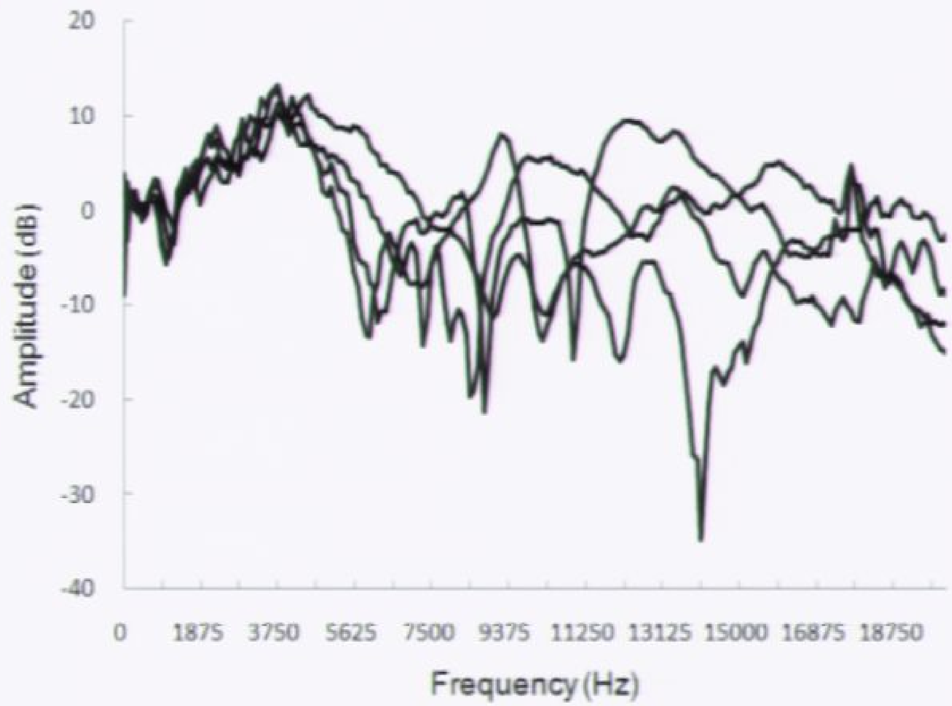

"An Approach to Individualization of head-related transfer functions based on the spectral cues for sound localization." Kazuhiro IIDA

The Pinna

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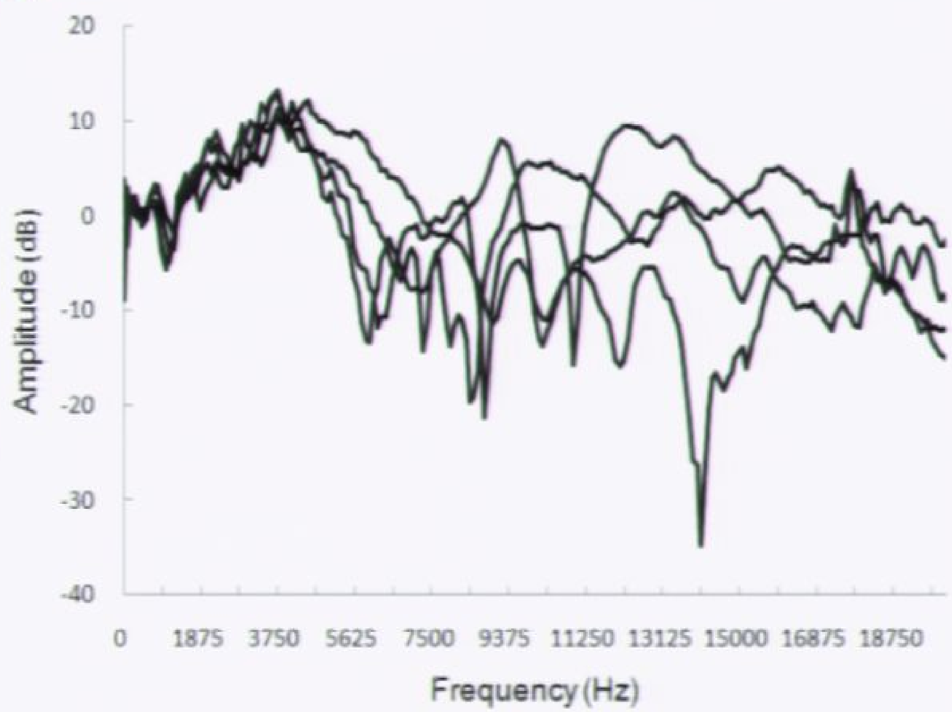

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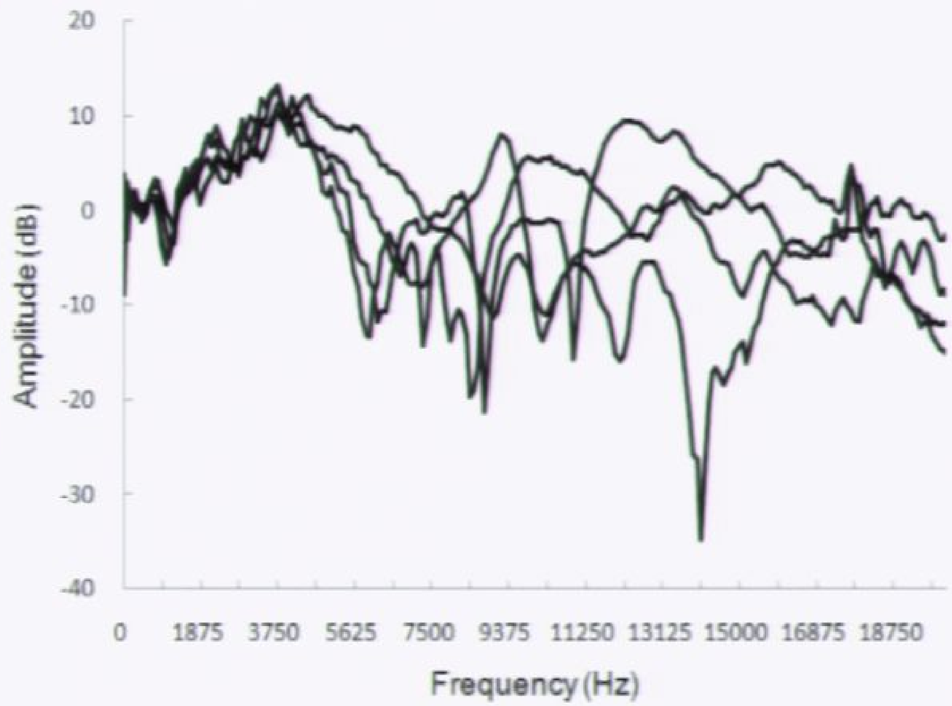

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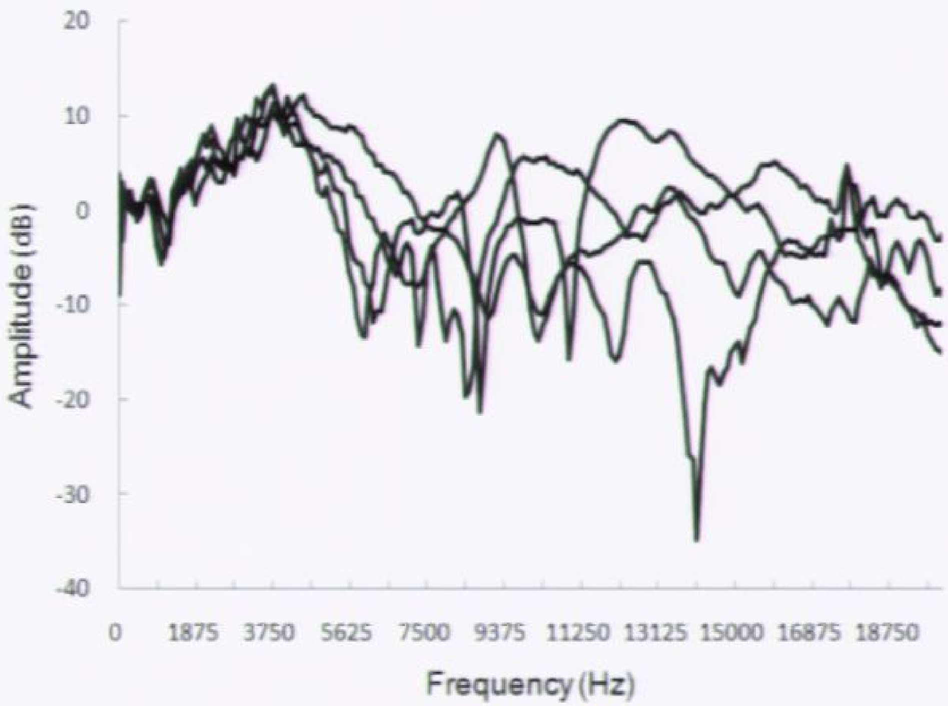

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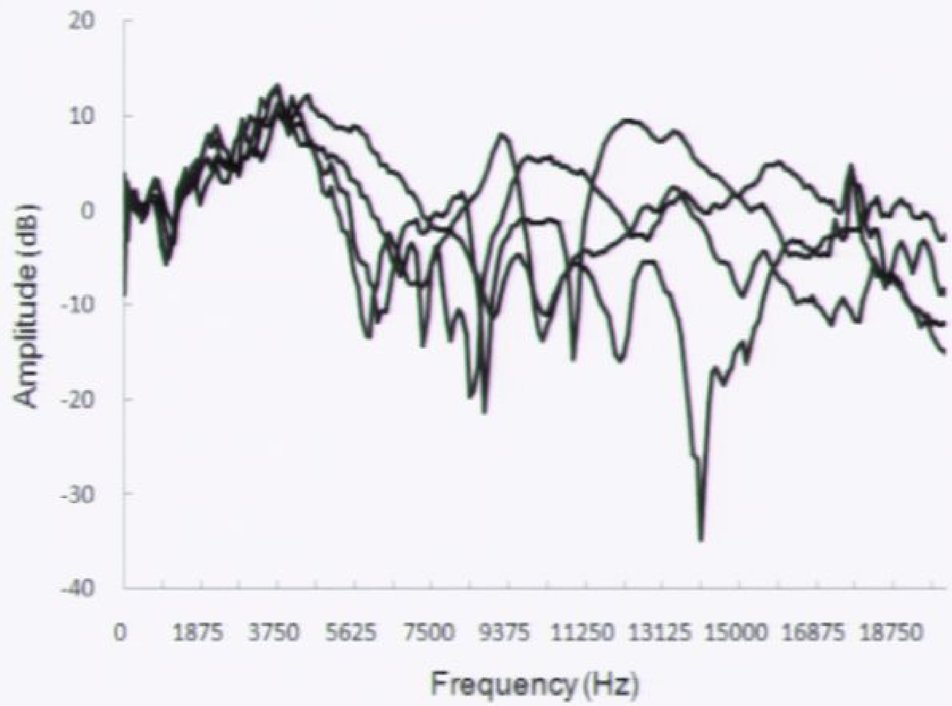

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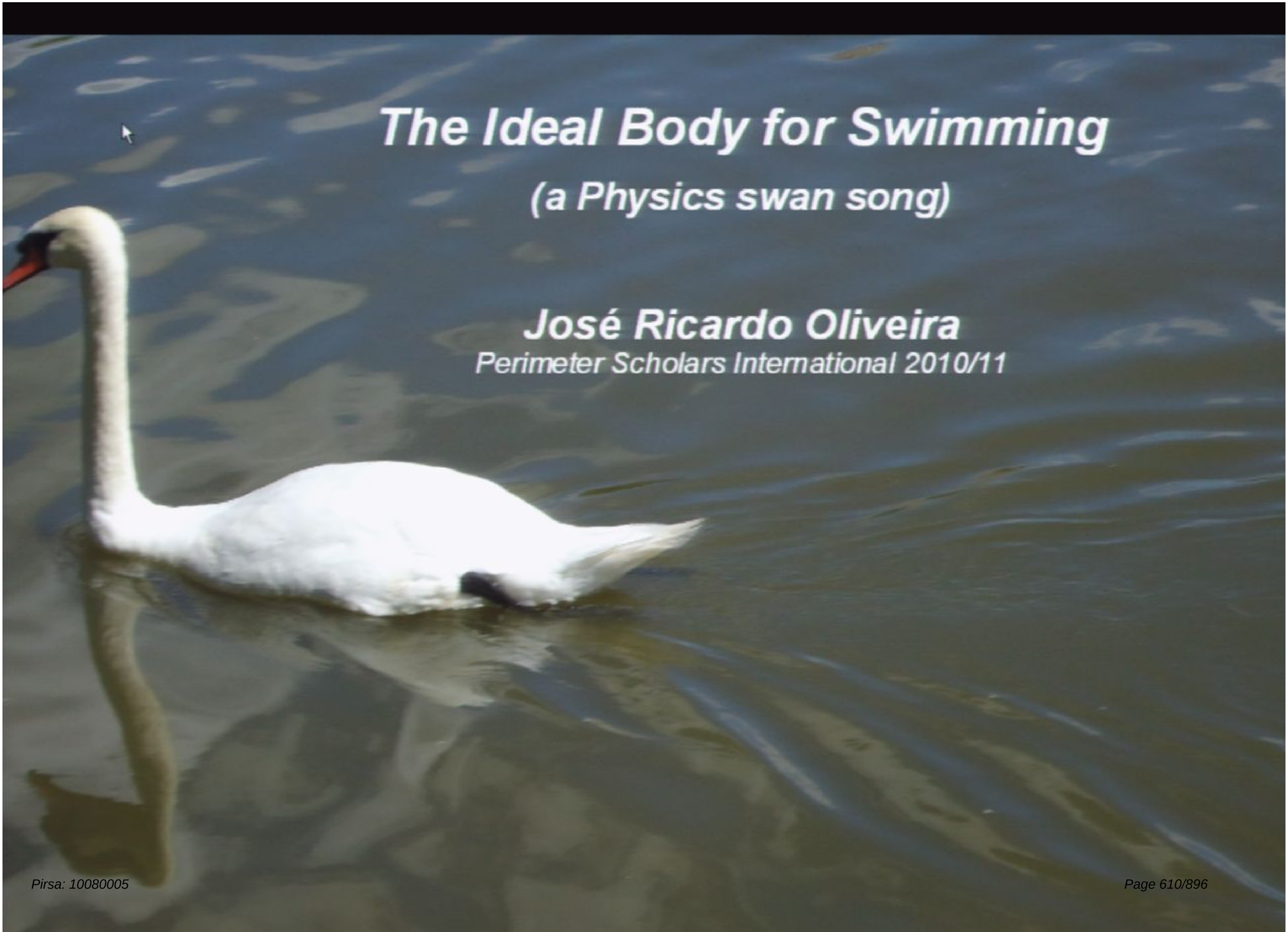
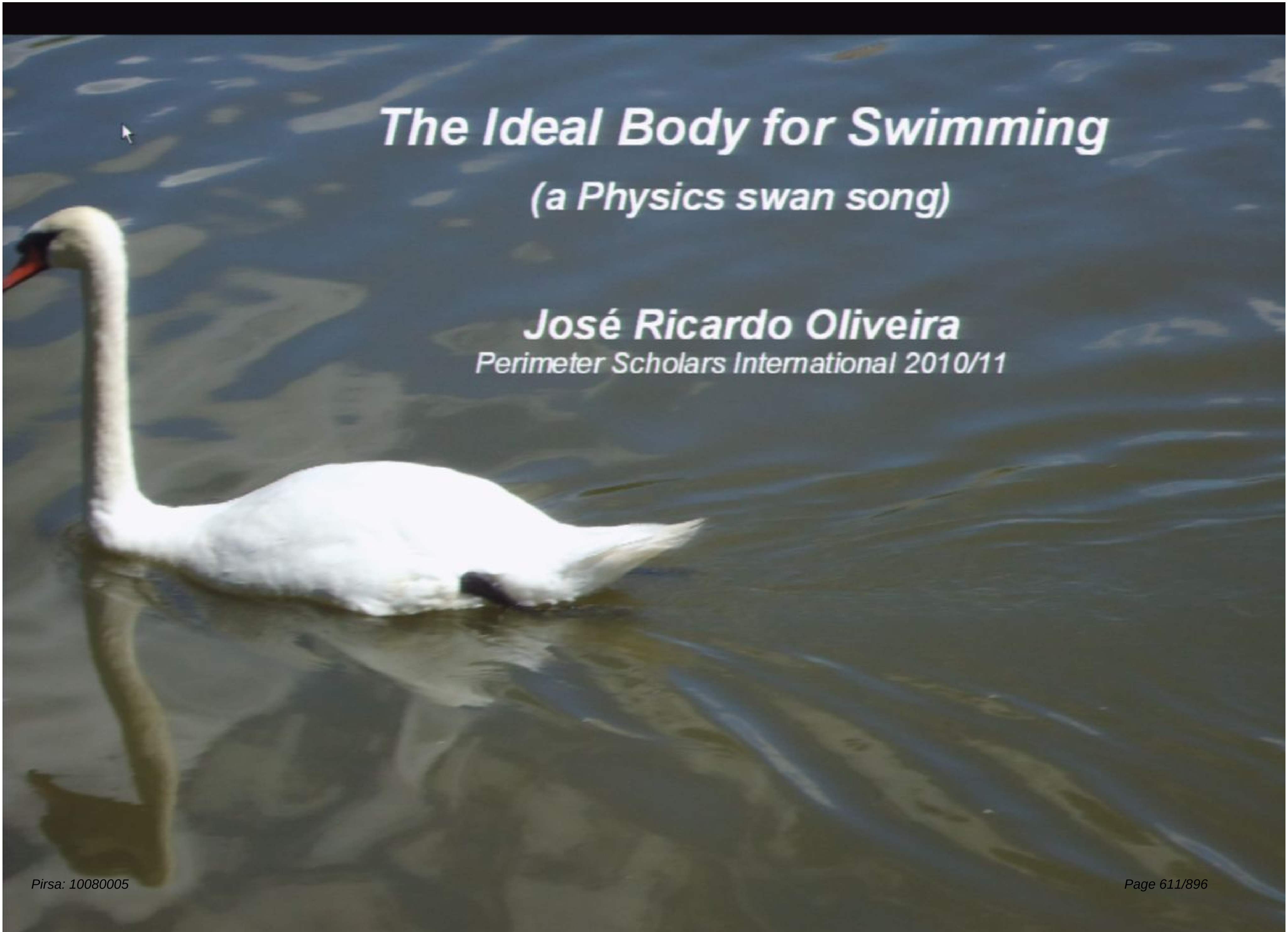

The Ideal Body for Swimming
(a Physics swan song)
José Ricardo Oliveira
Perimeter Scholars International 2010/11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Outline

We will discuss the influence of body shape in swimming, namely how an adequate shape can reduce drag:

- description of the fluid-dynamic problem;
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- Streamlined body shapes are seen in most waterbound and flying animals; do they serve a purpose in swimming?

Image: flyfishingnature.com

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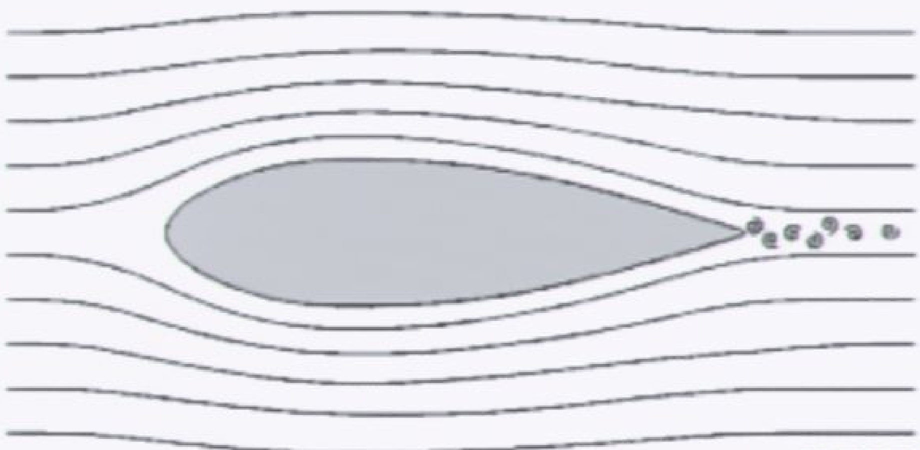

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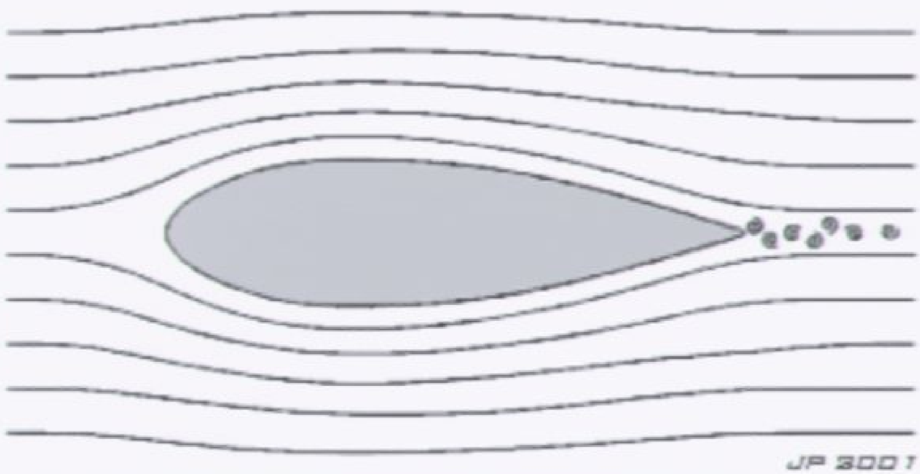

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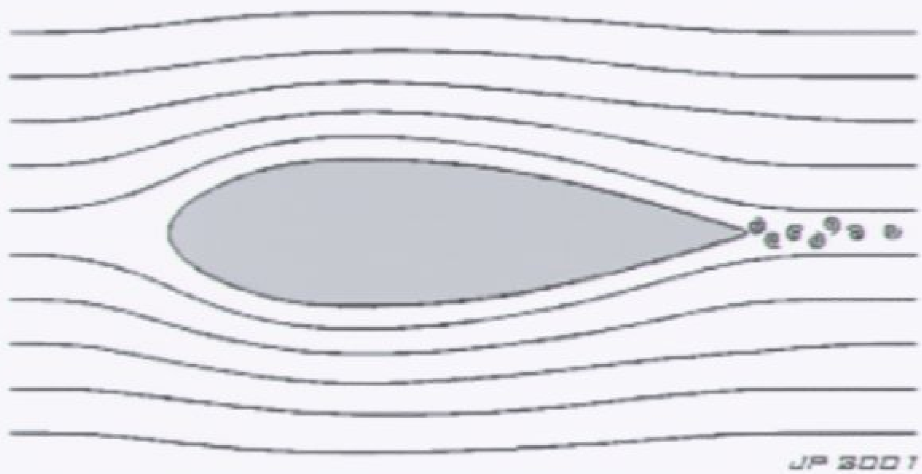

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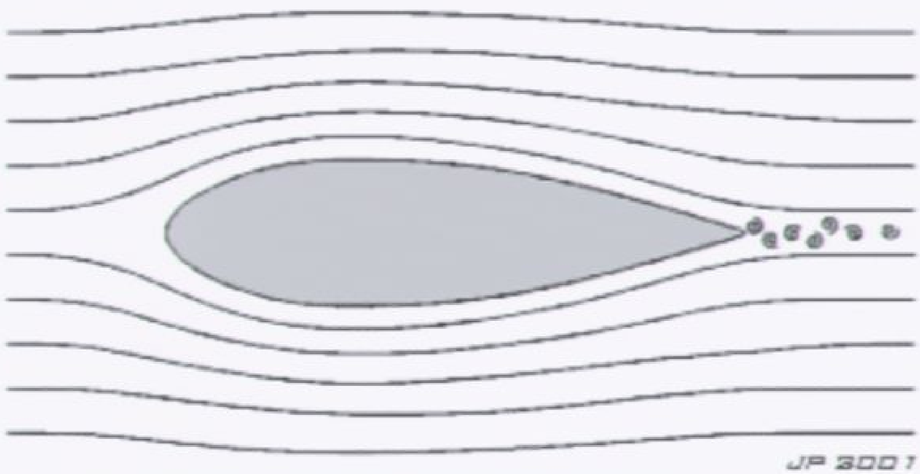

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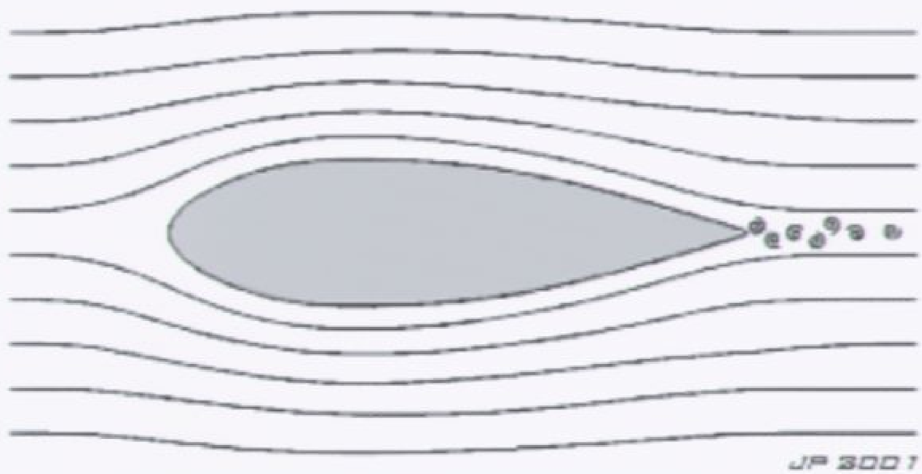

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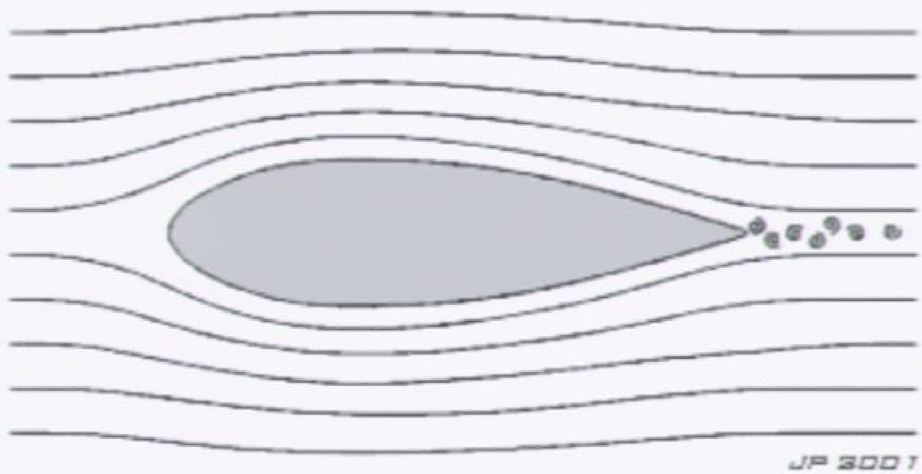

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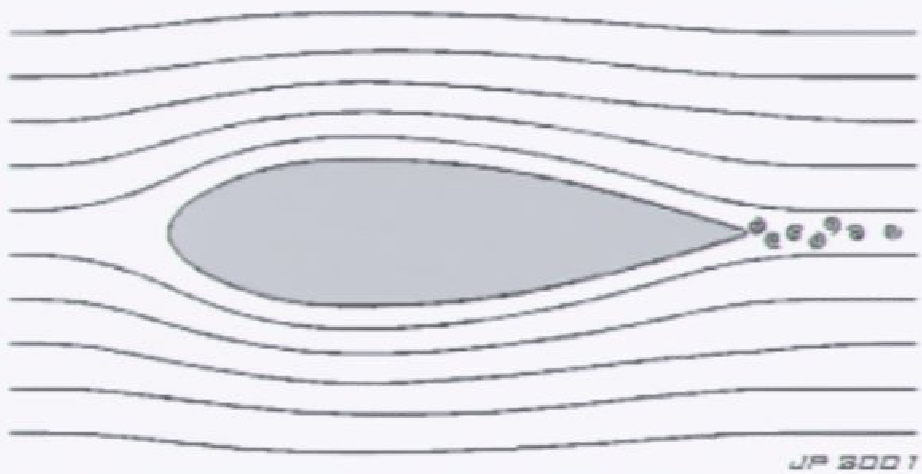

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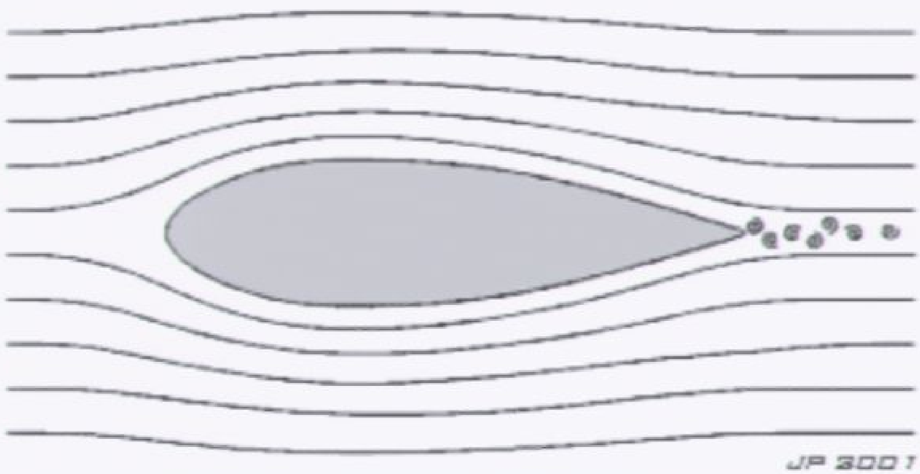

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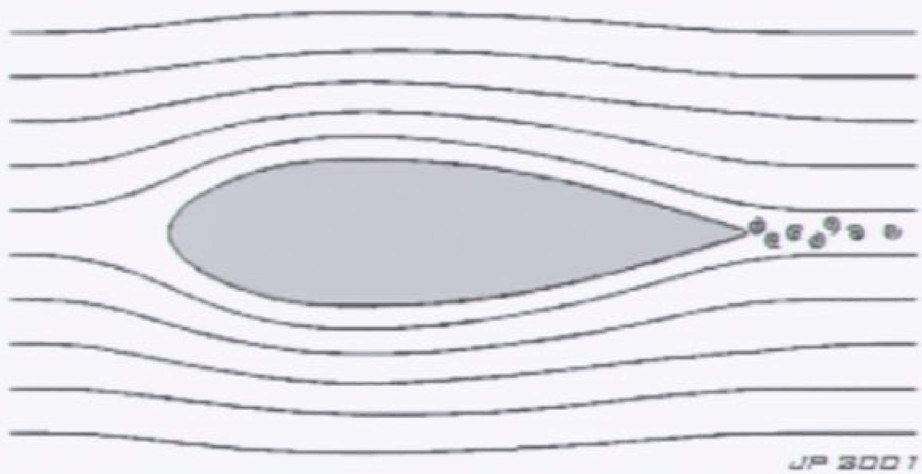

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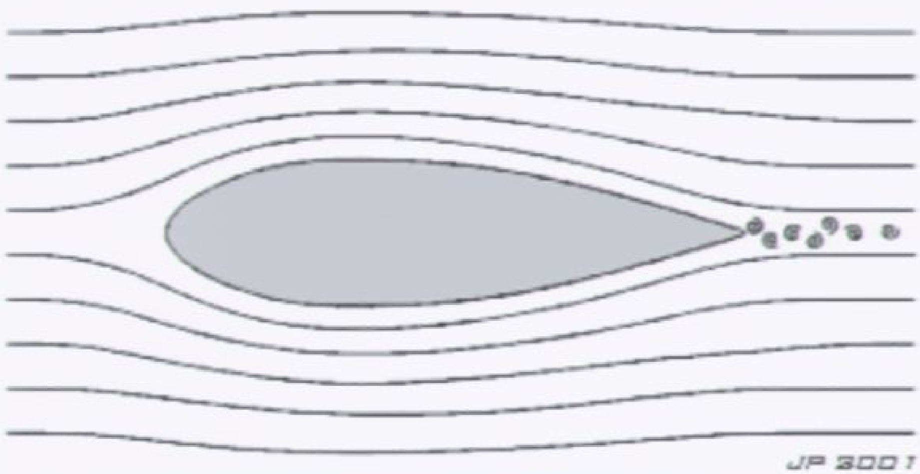

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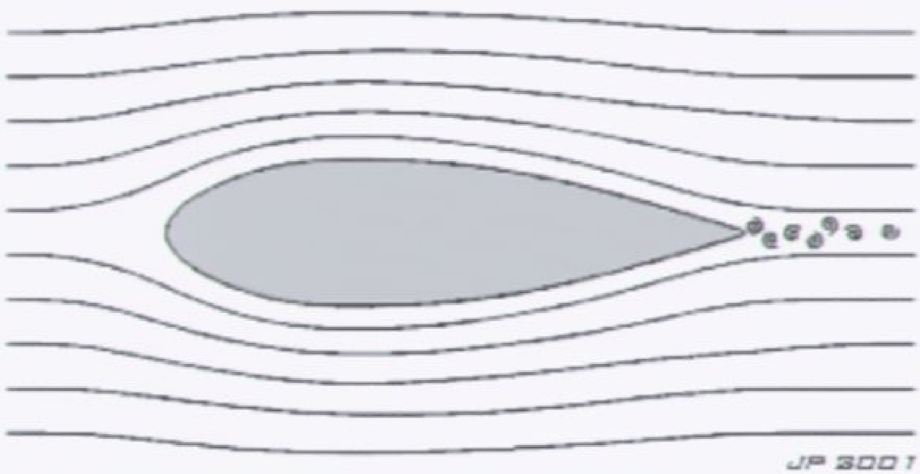

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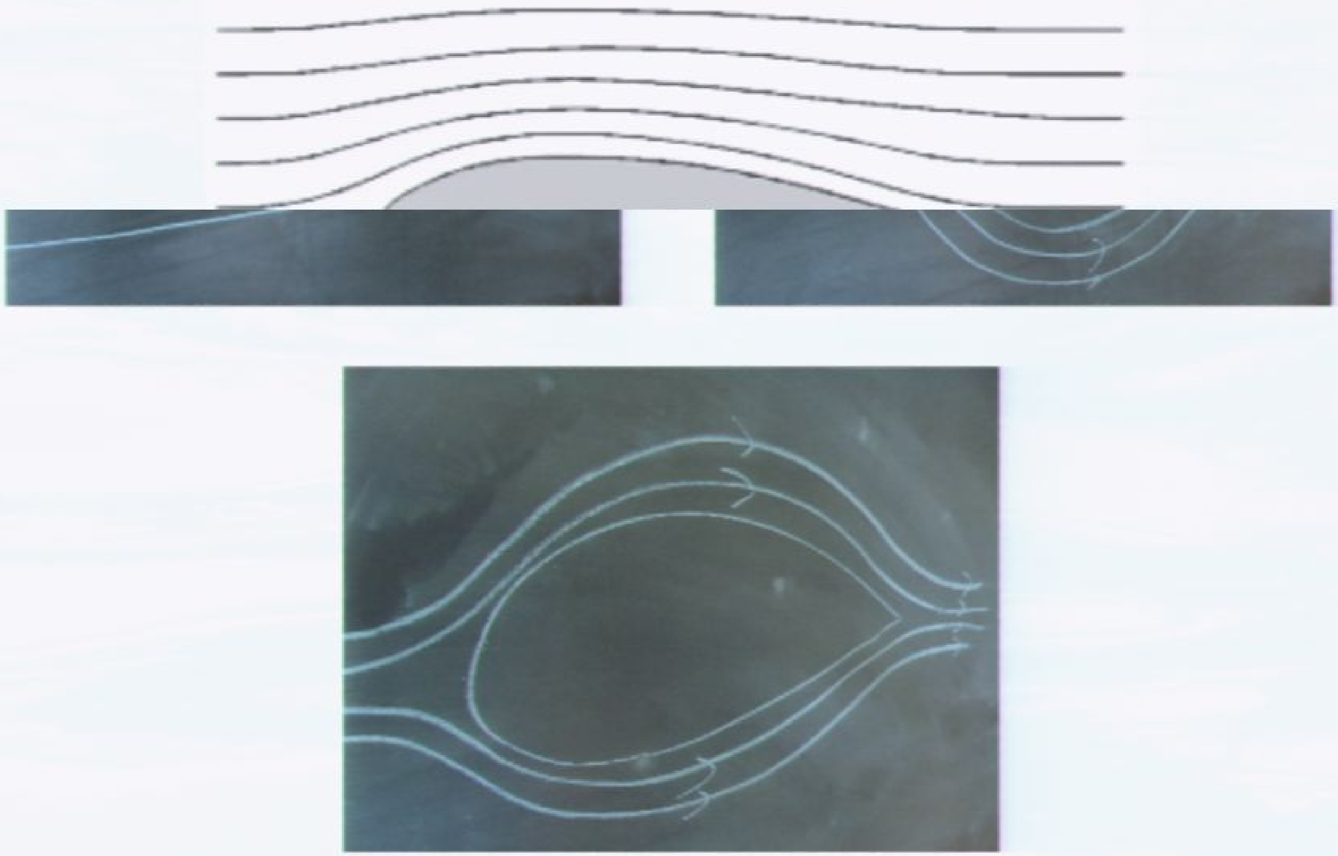
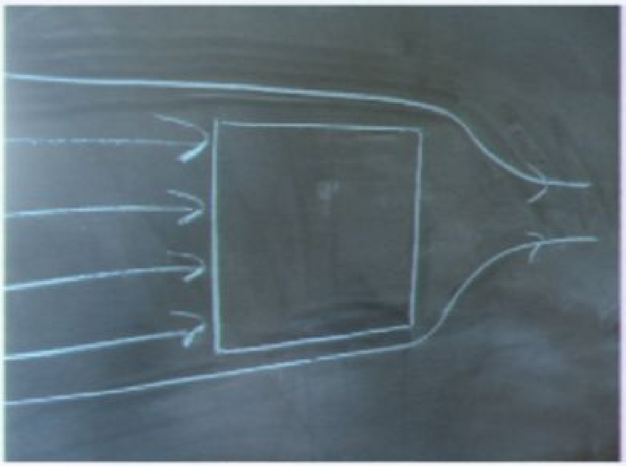
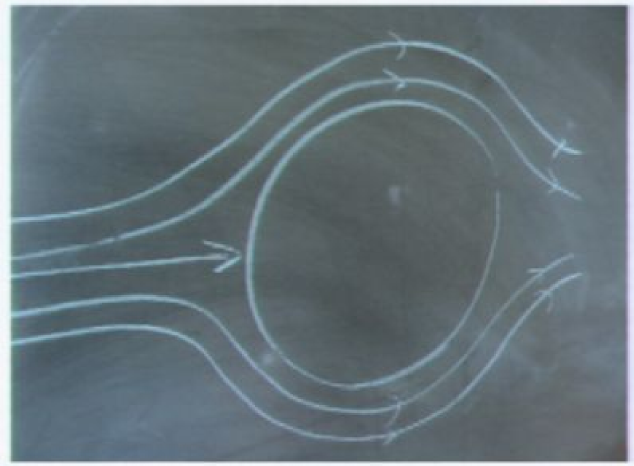
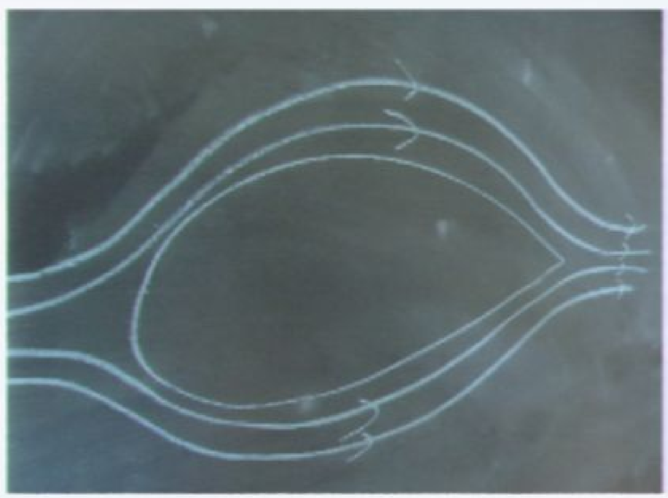


- Let us try to gain some intuition on which shapes are more efficient:

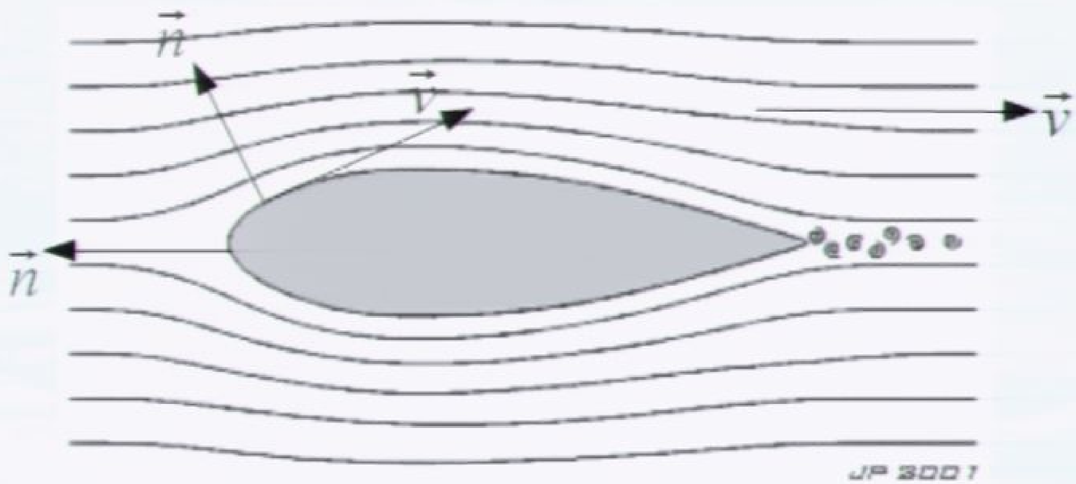






1. Outline of the physical problem

- Consider the flow of a viscous fluid past an obstacle (equivalent to the swim of a body in a previously static fluid):



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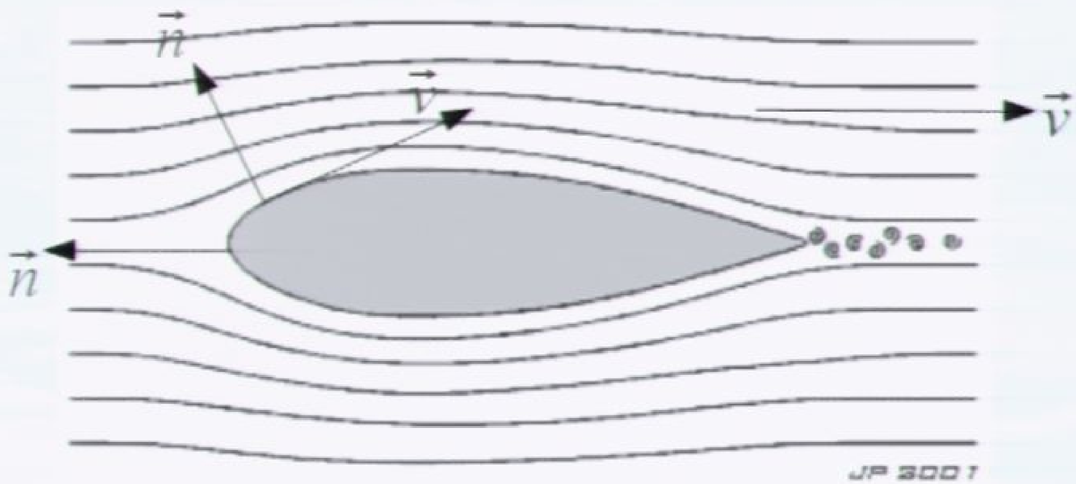

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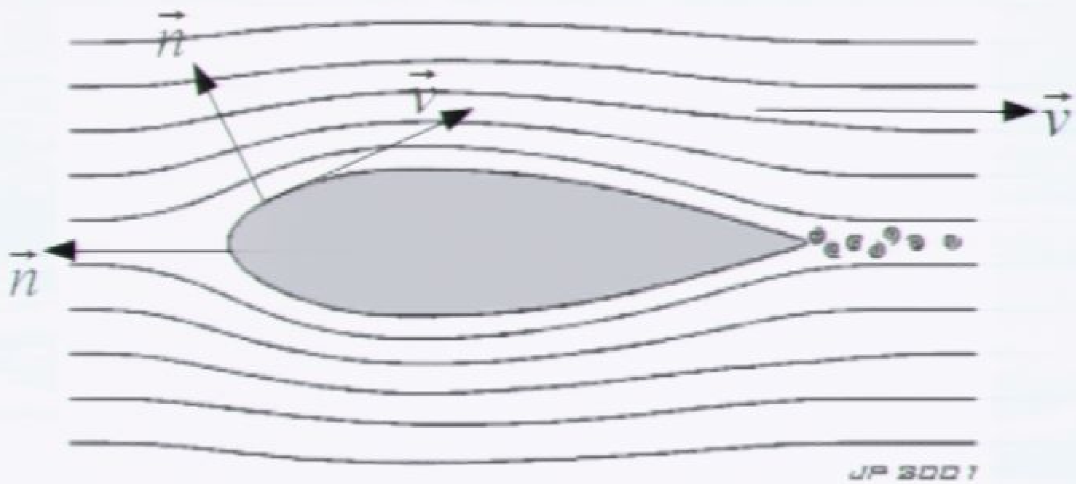

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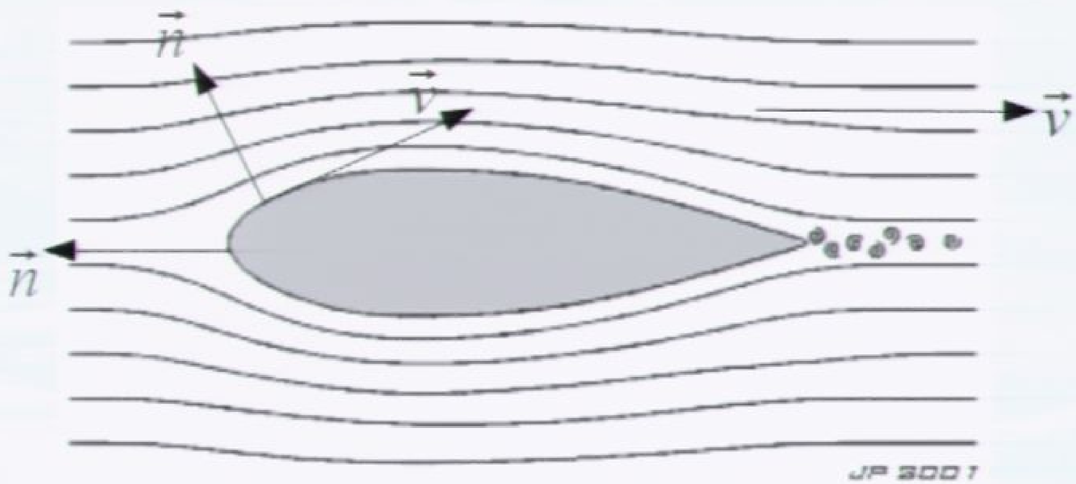

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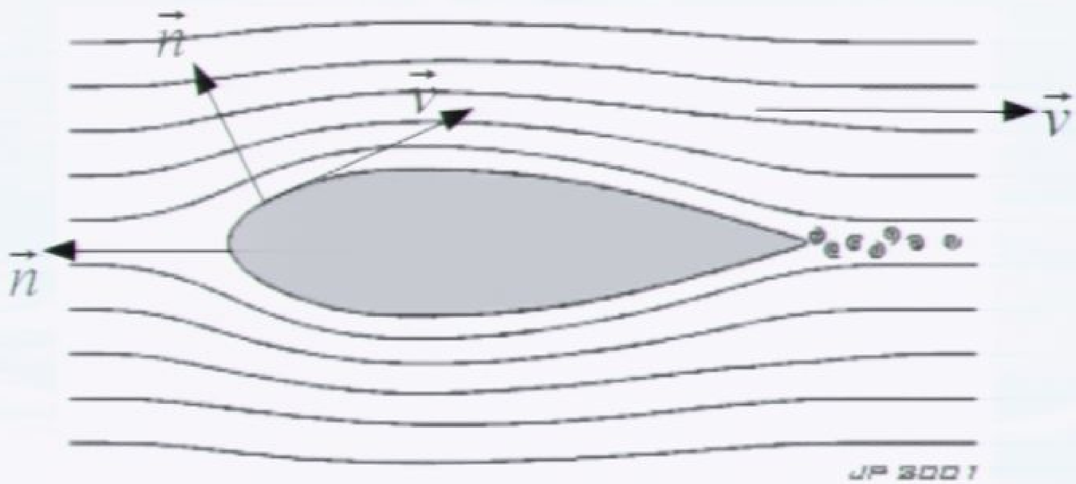

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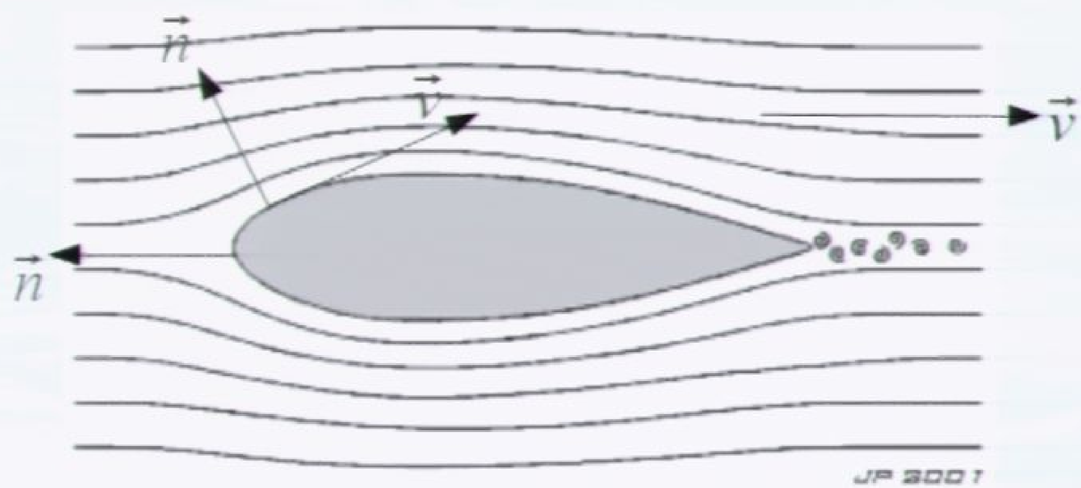

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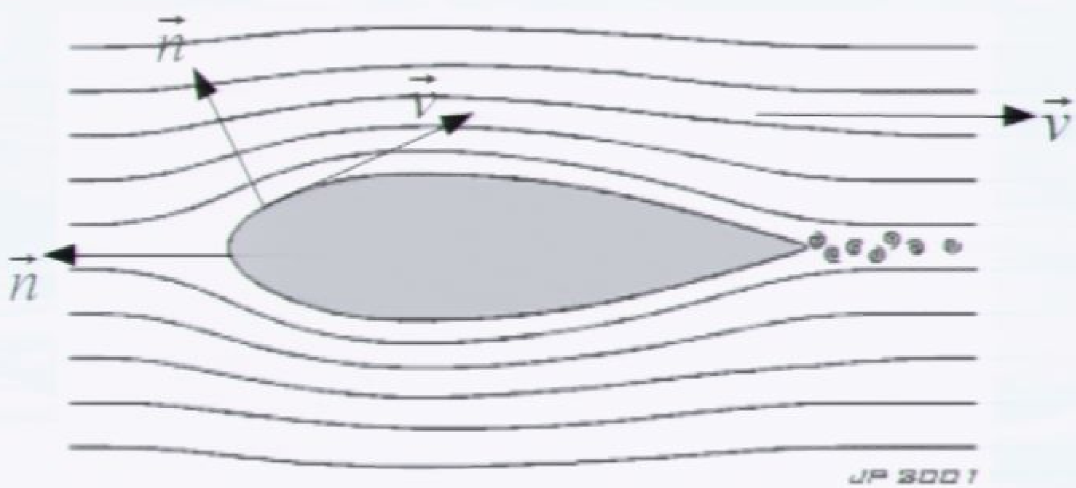

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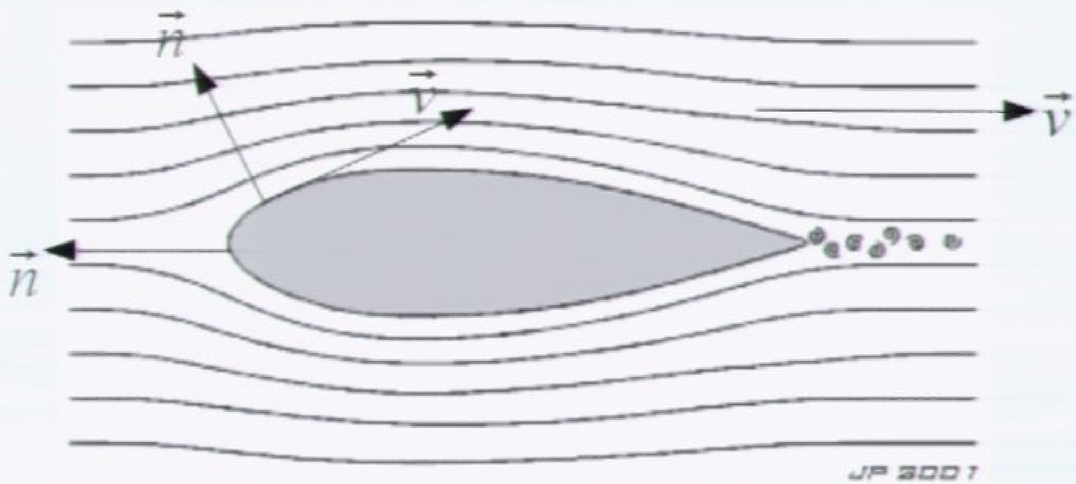

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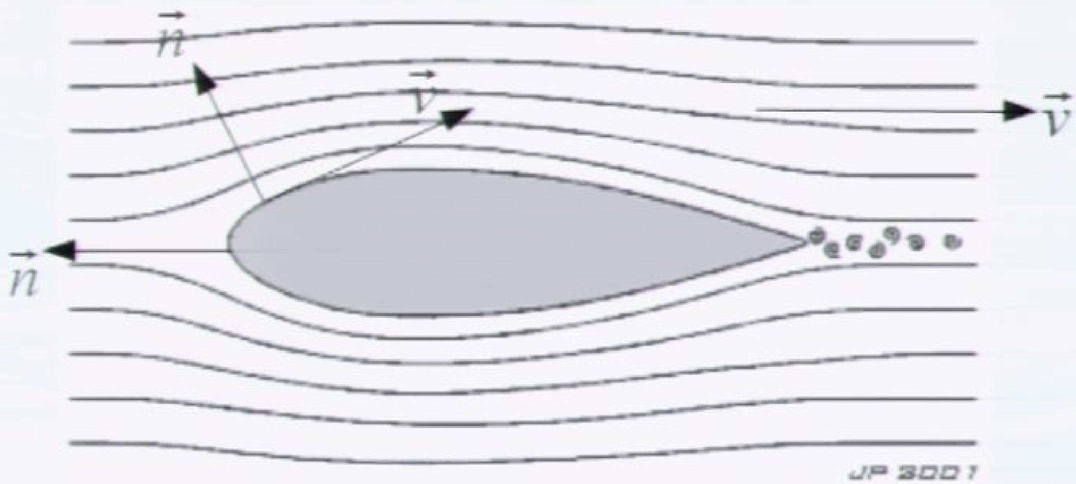

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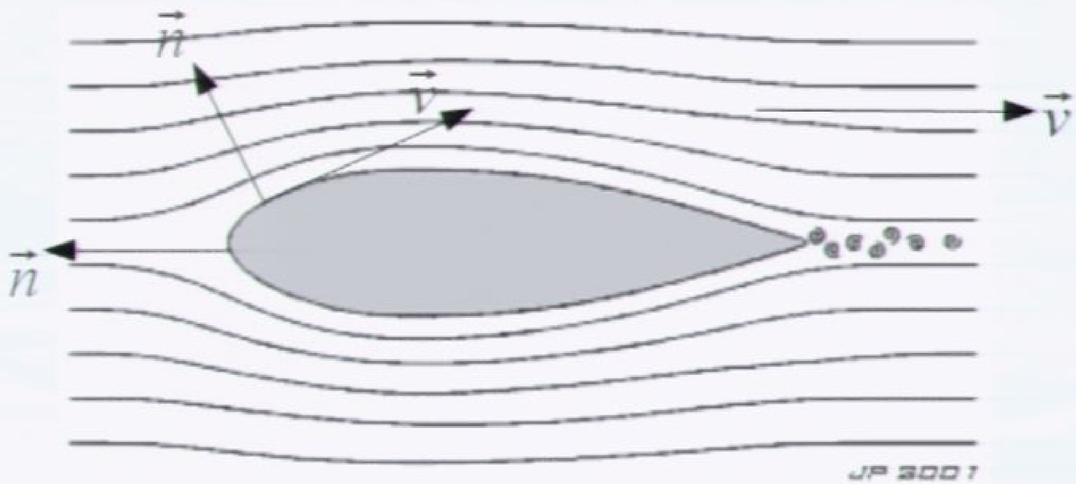

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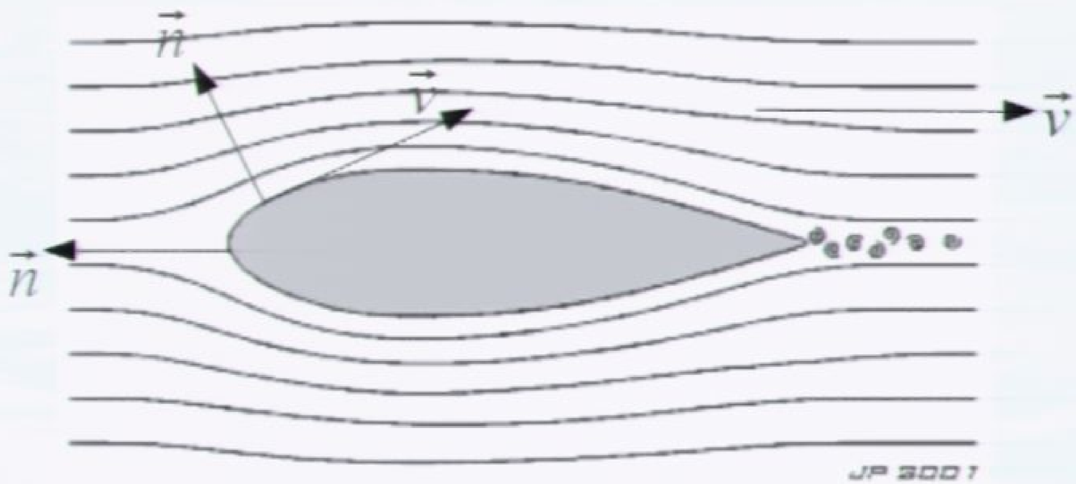

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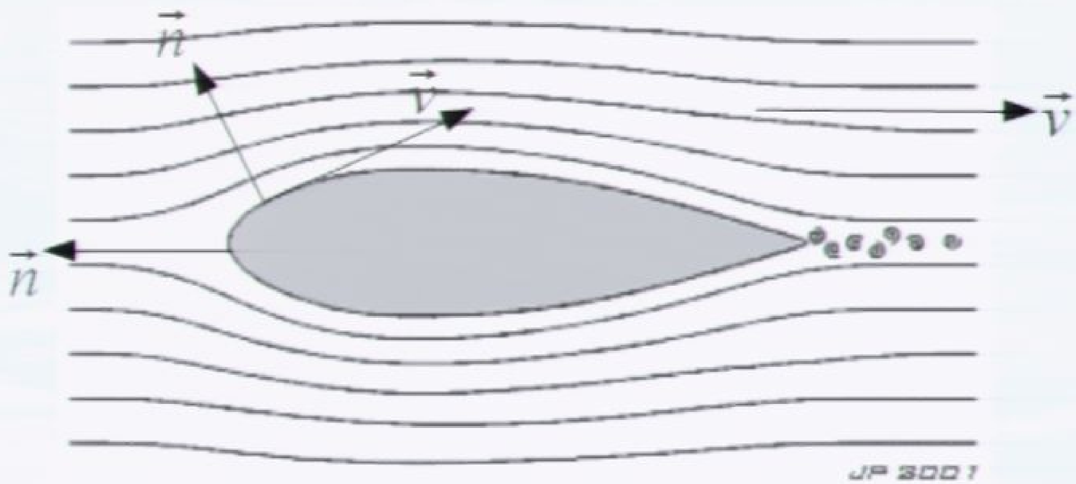

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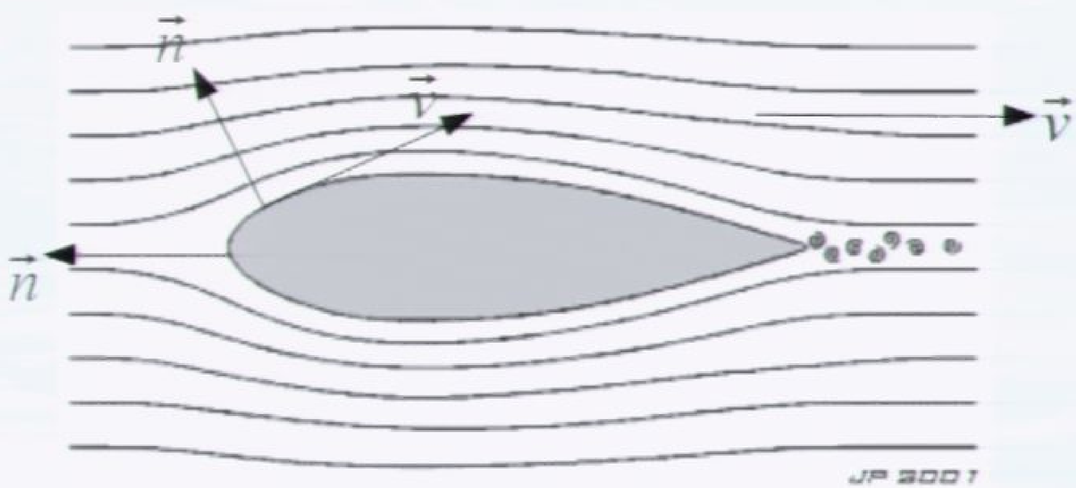

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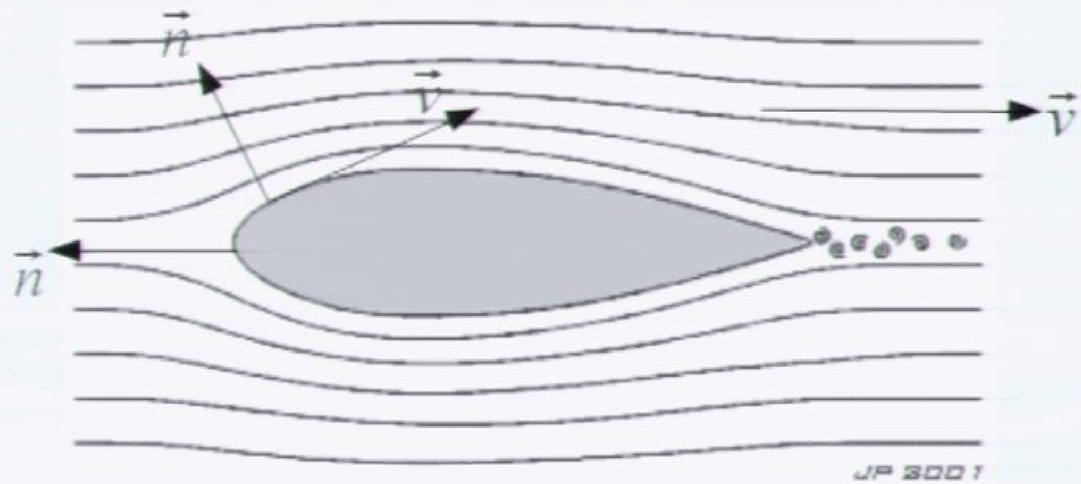

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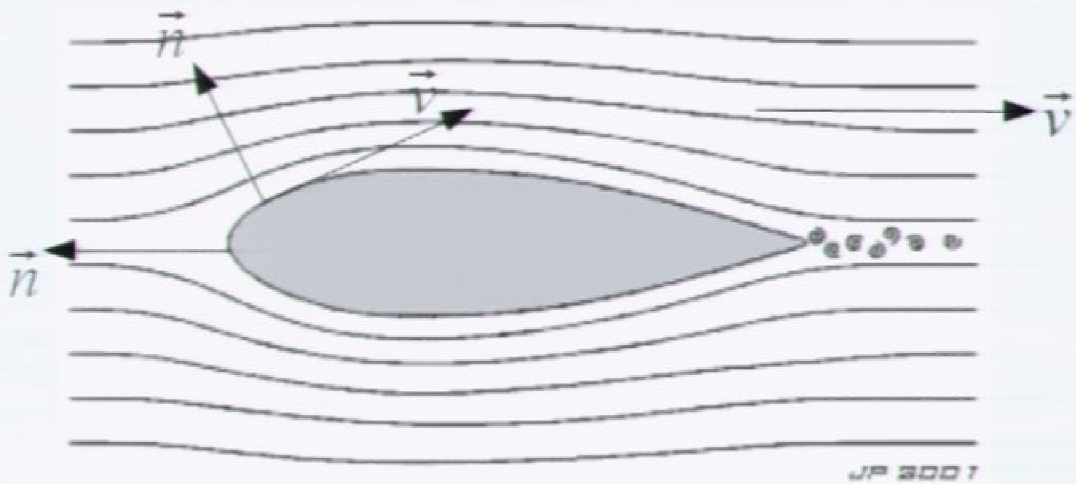

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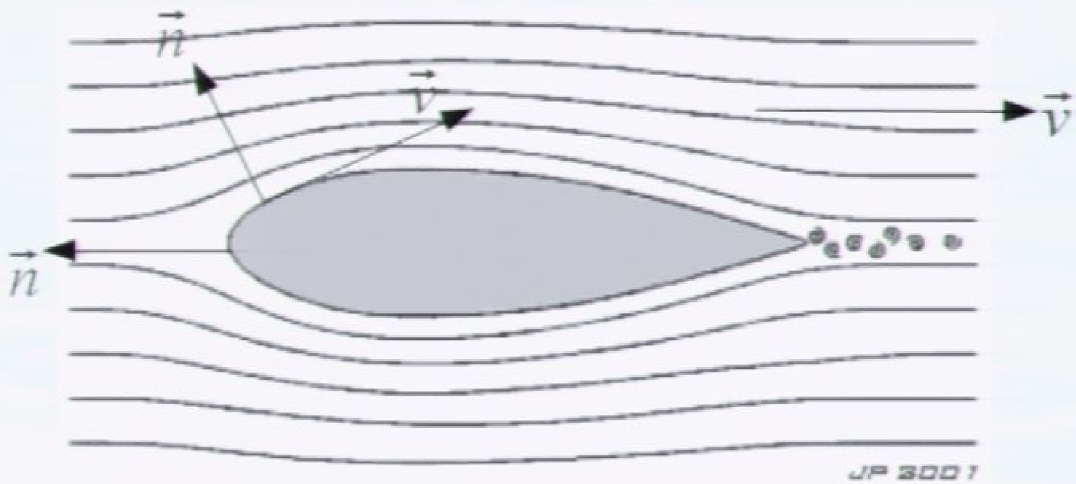

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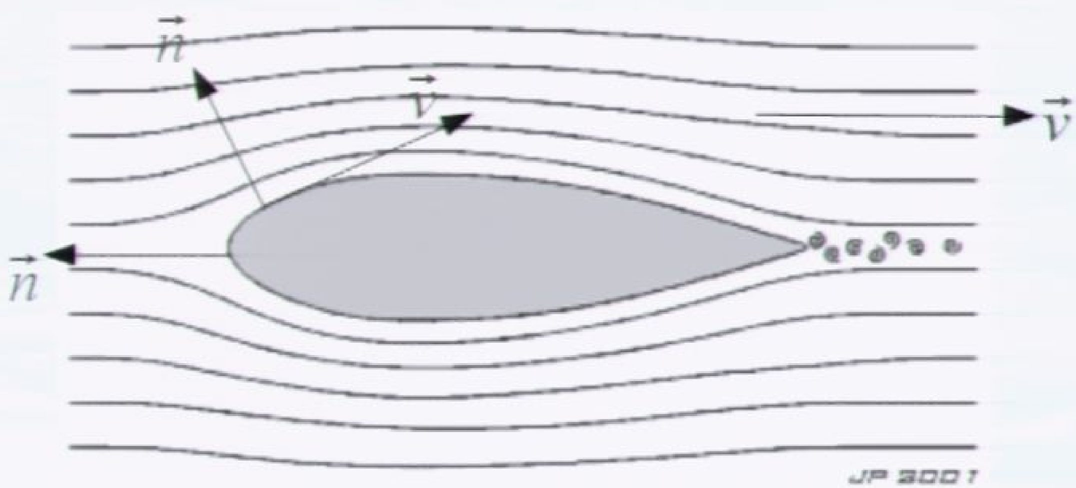

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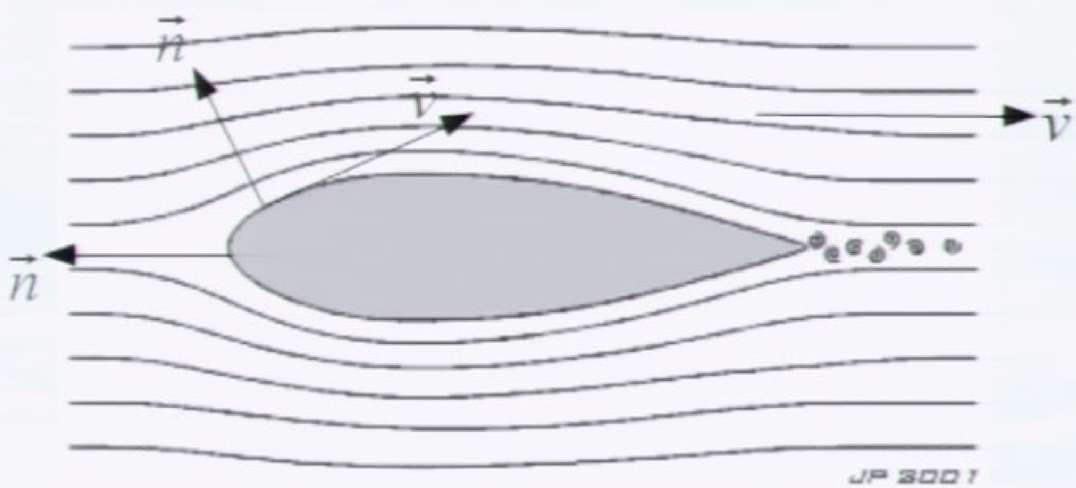

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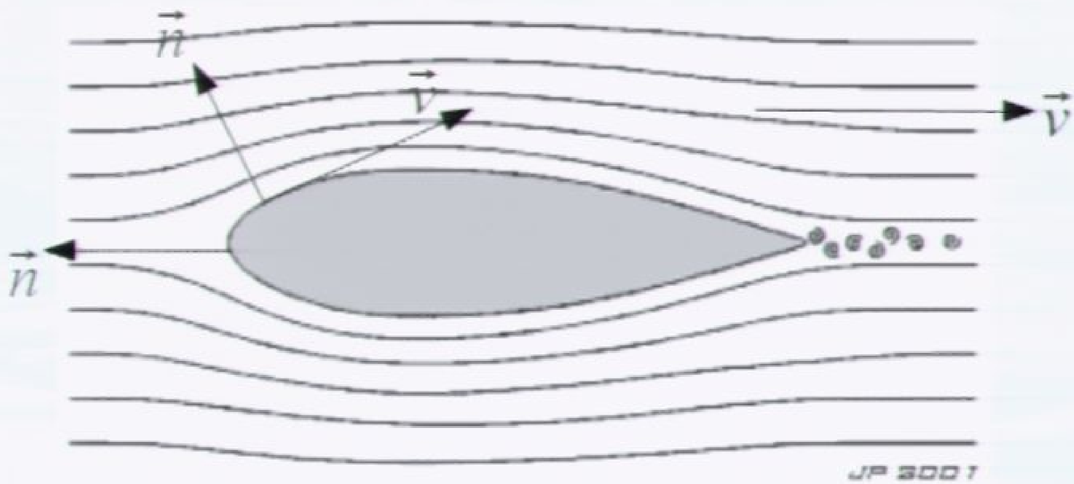

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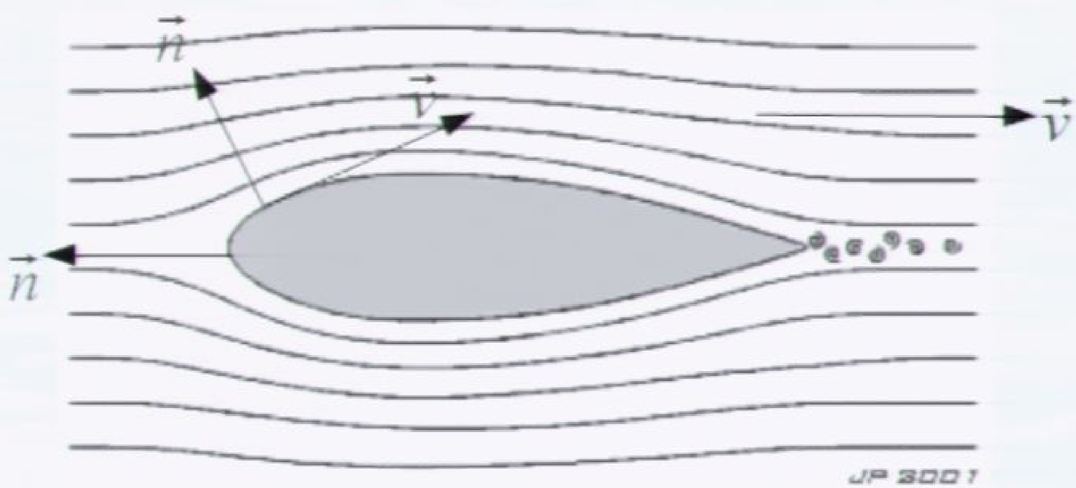

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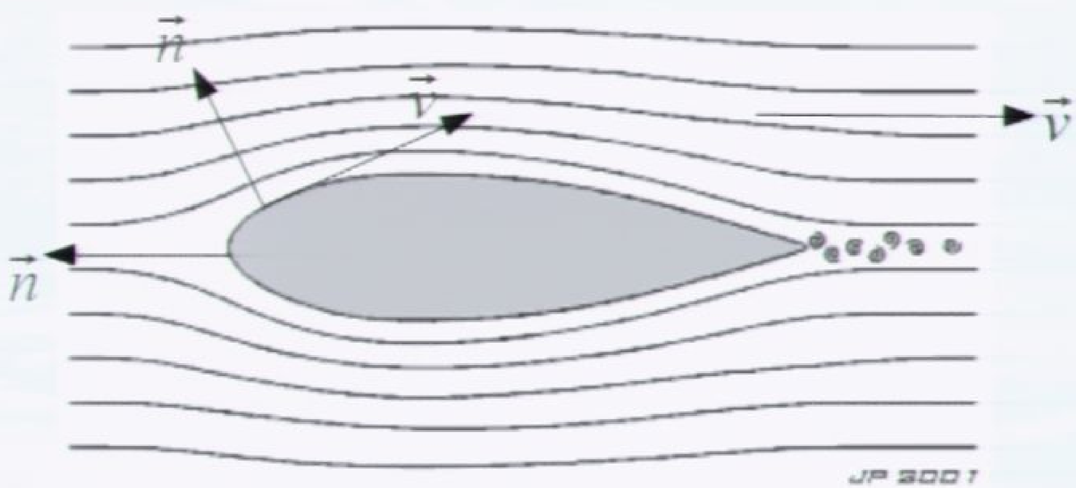

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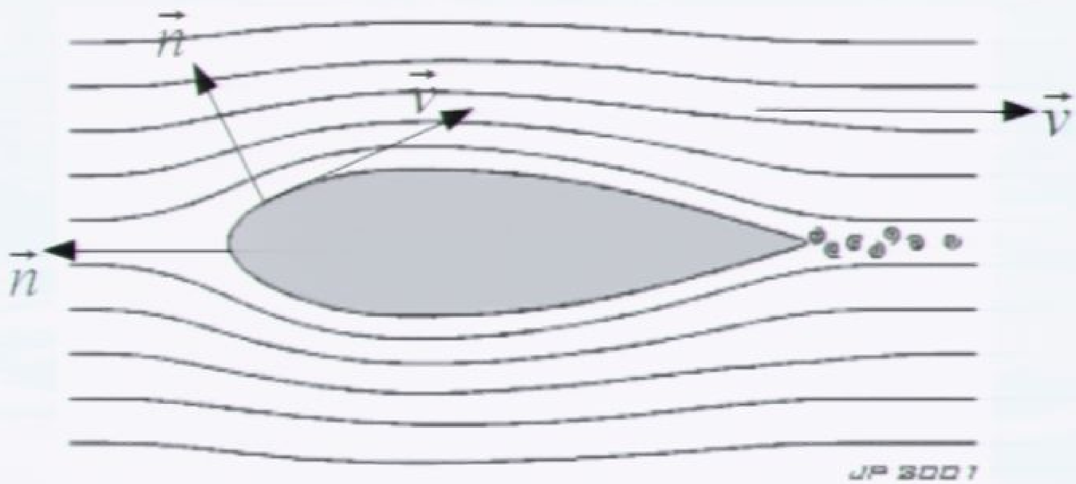

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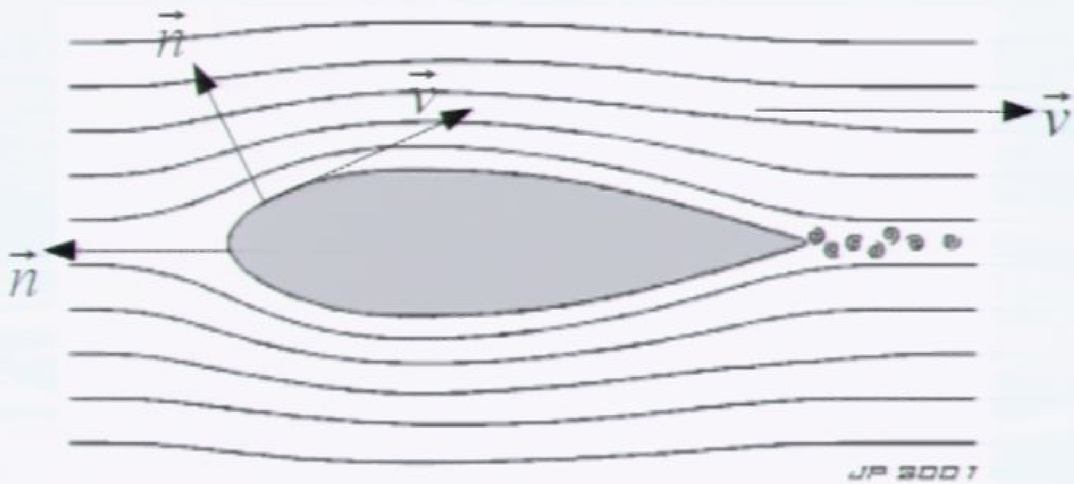

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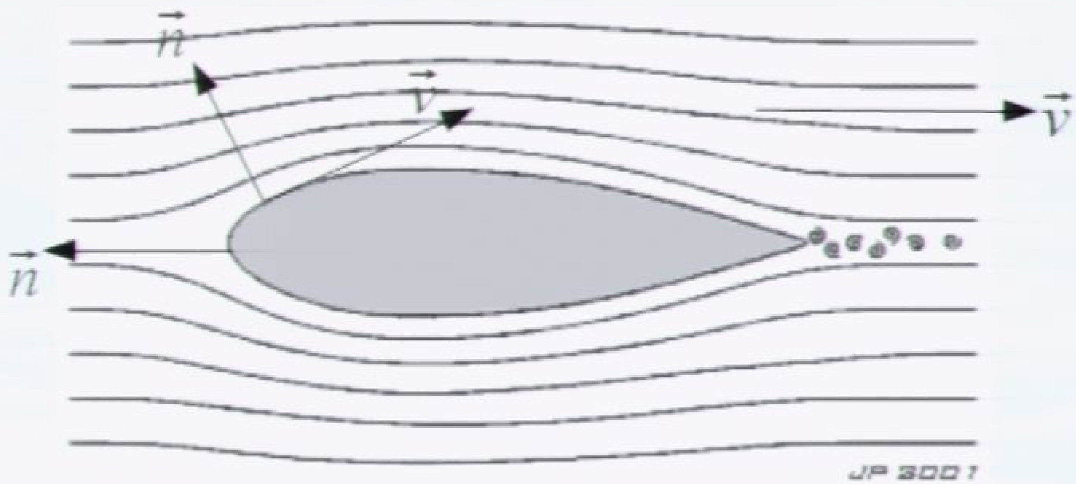

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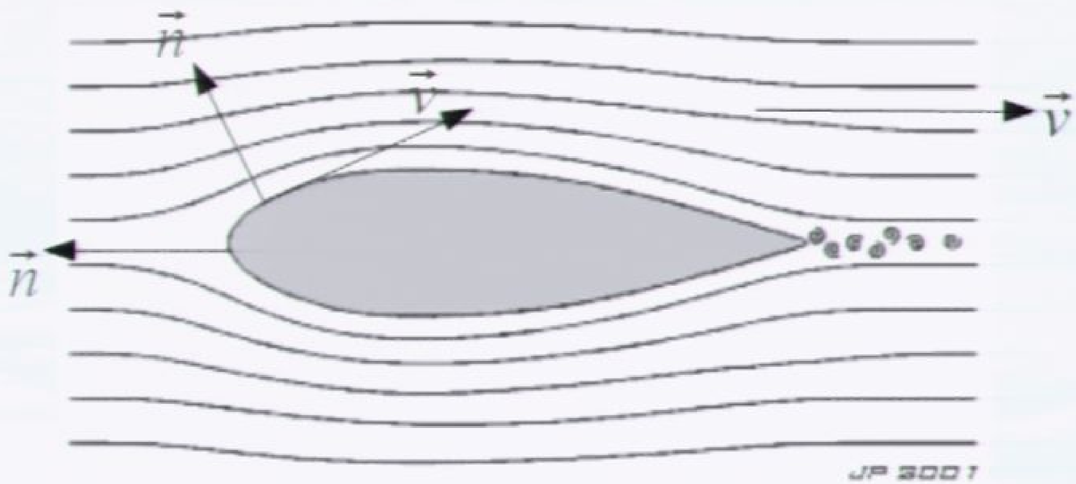

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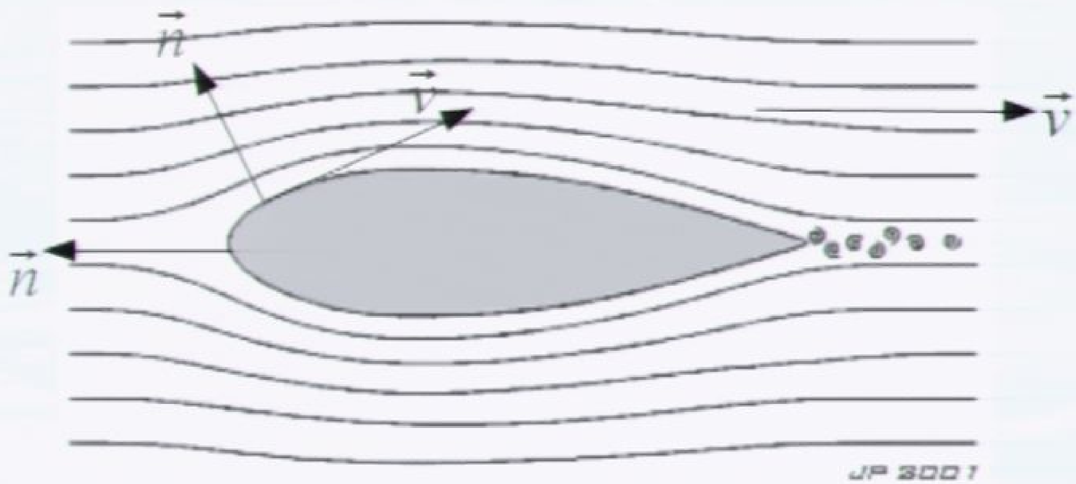

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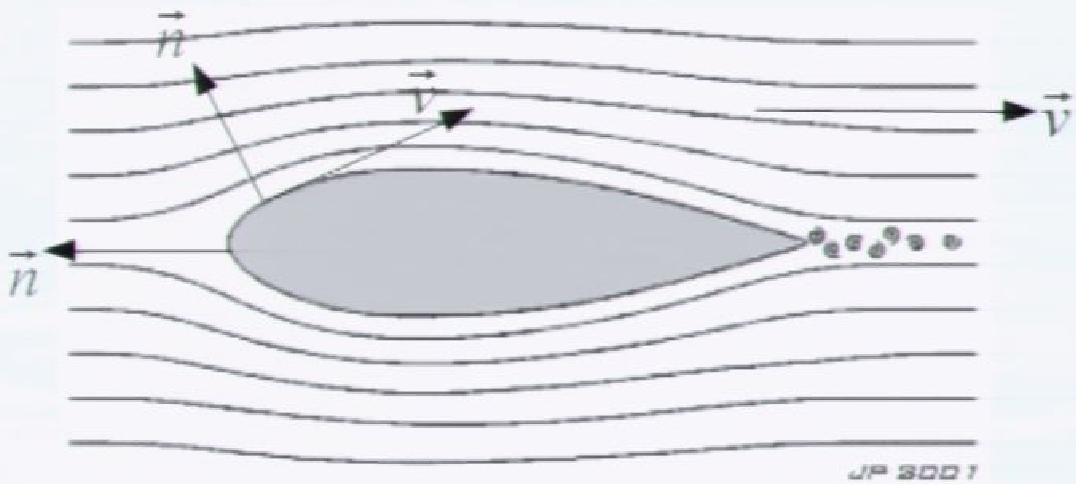

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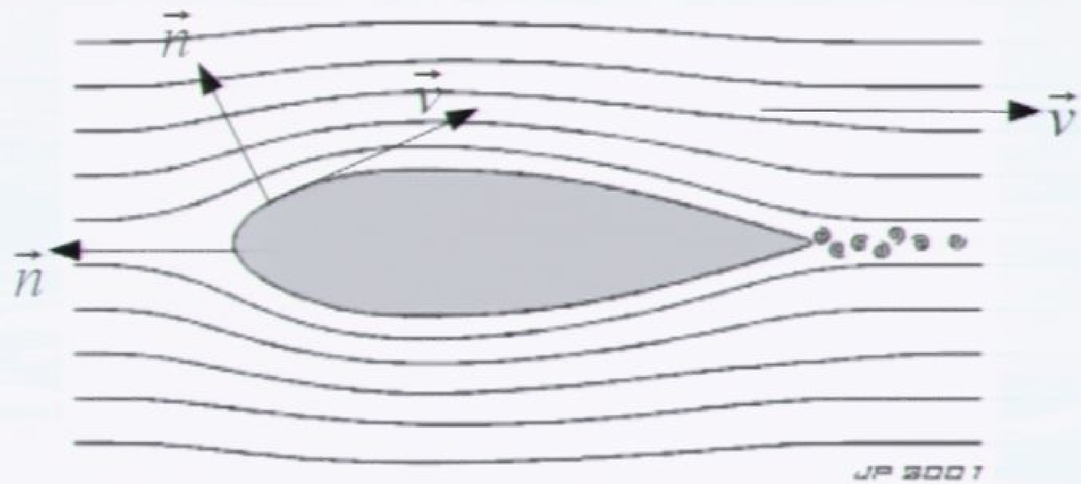

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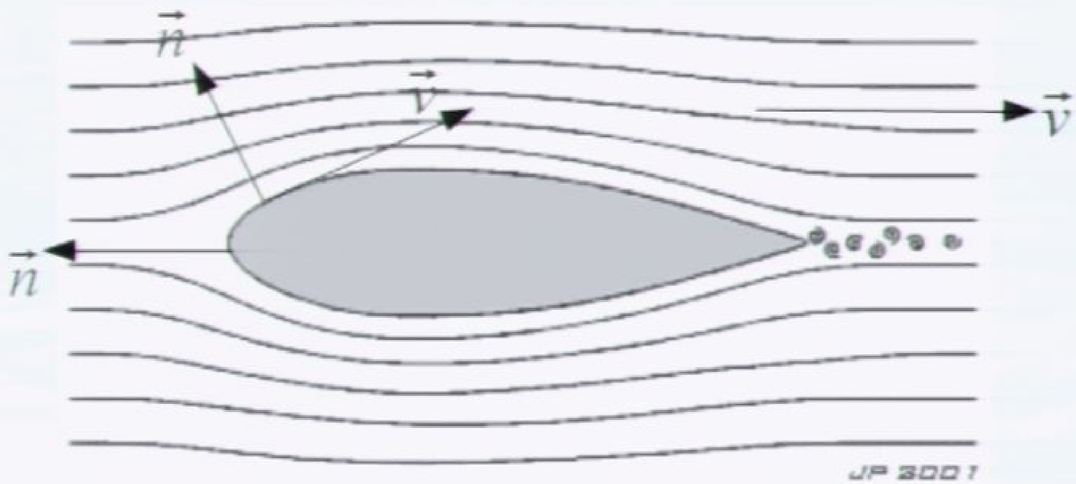

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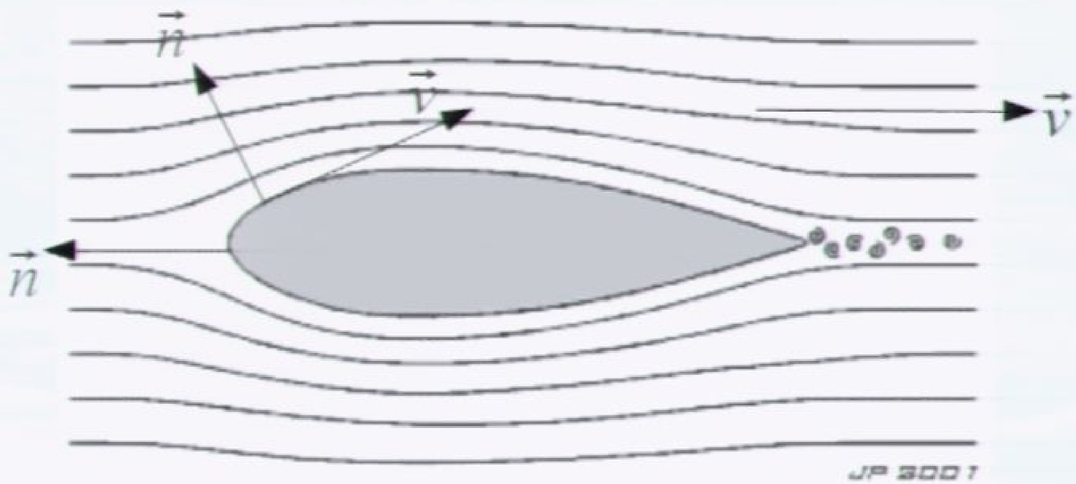

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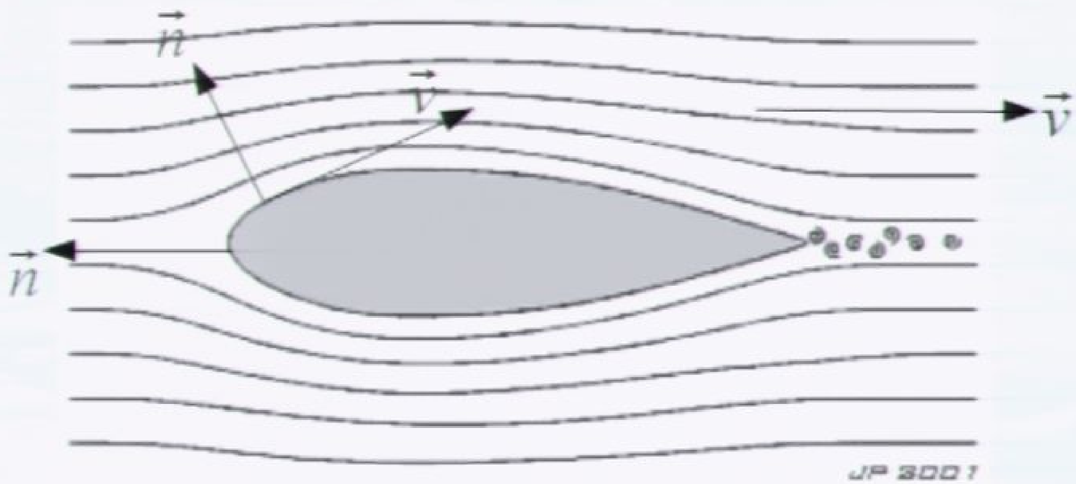

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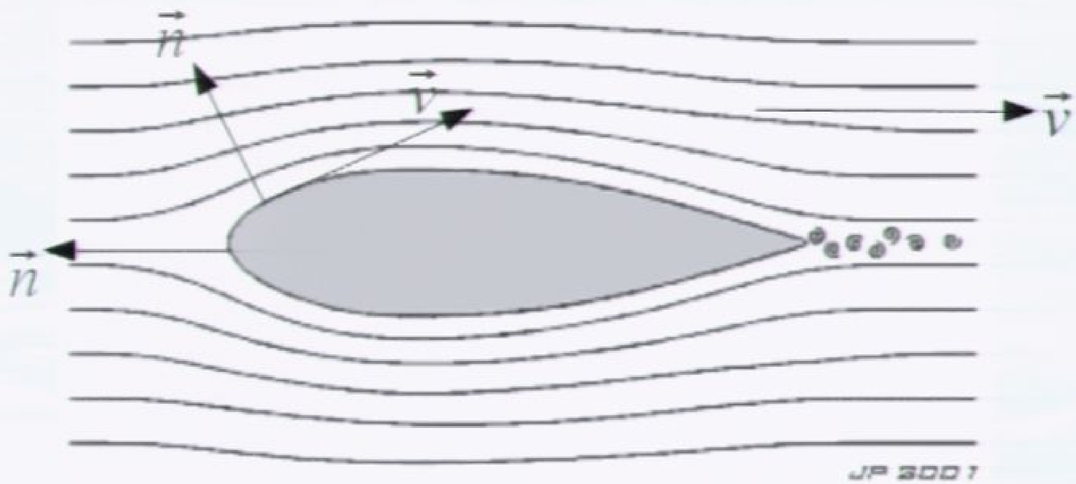

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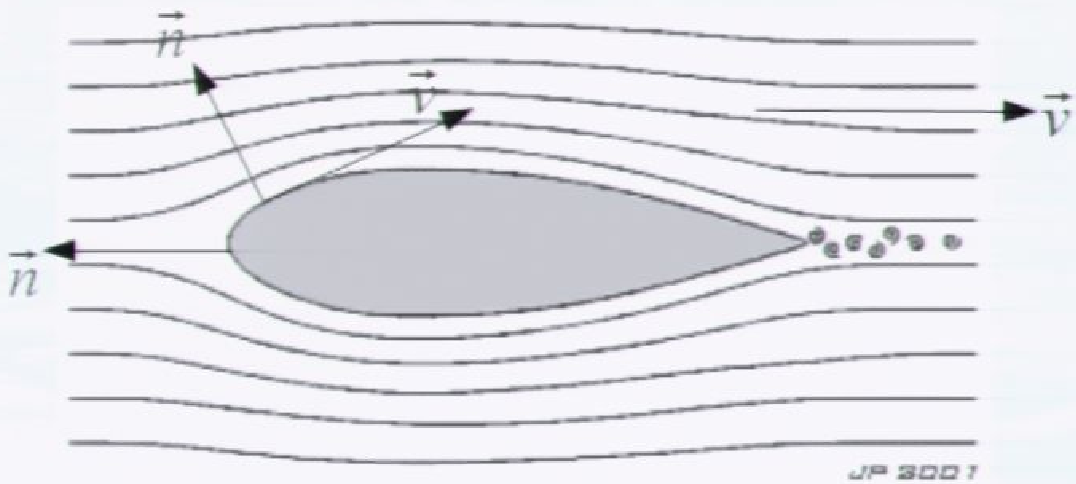

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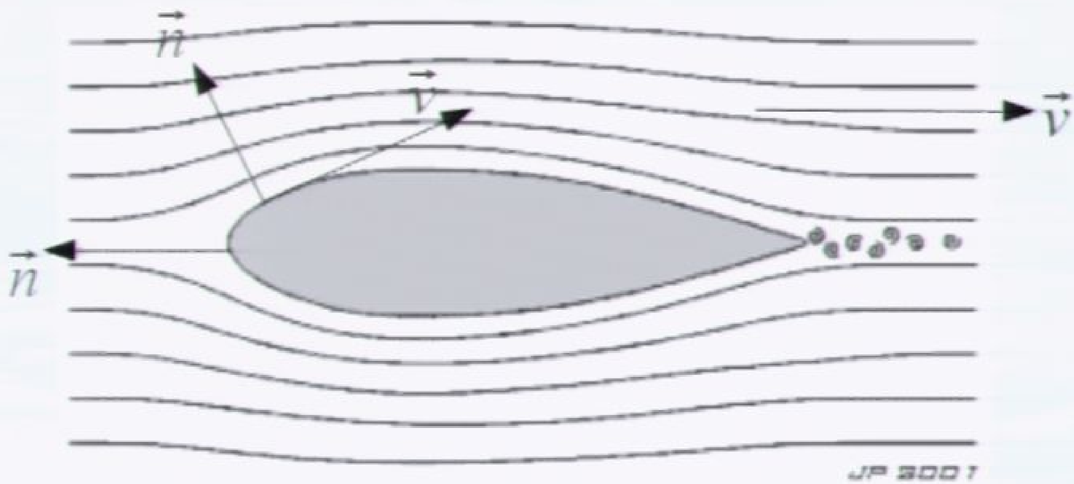

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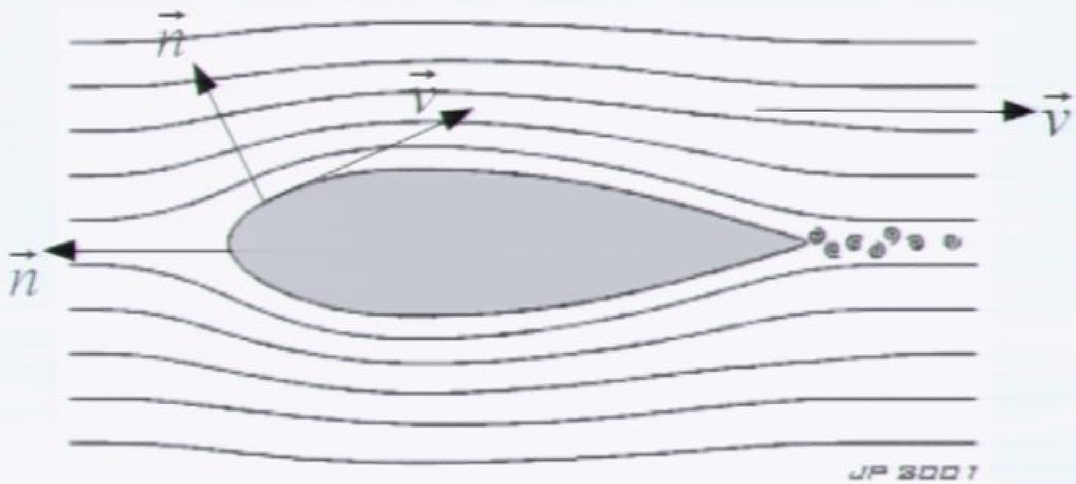

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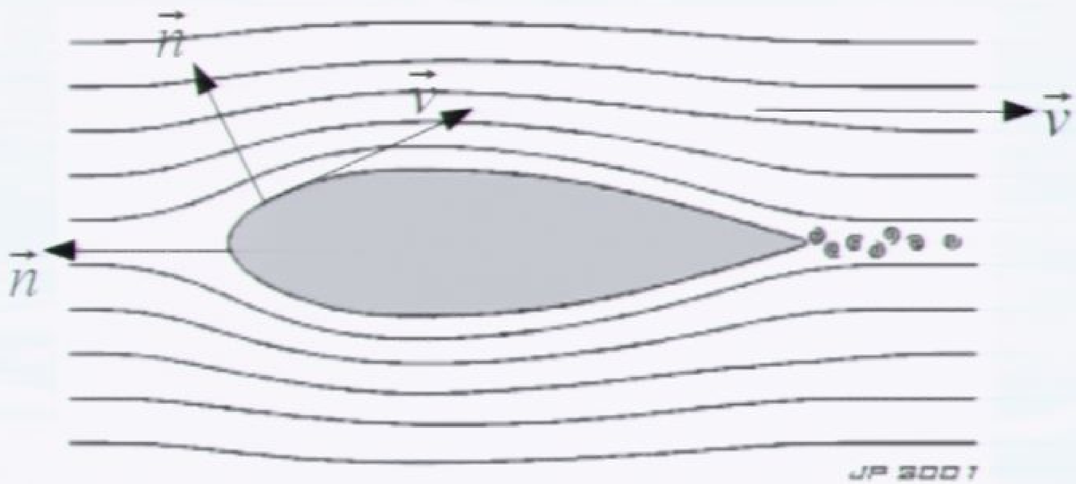

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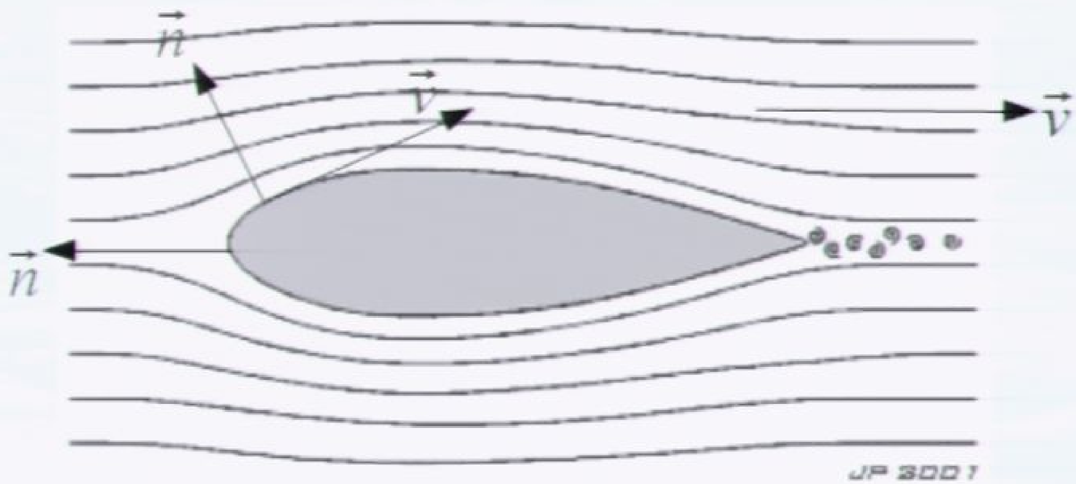

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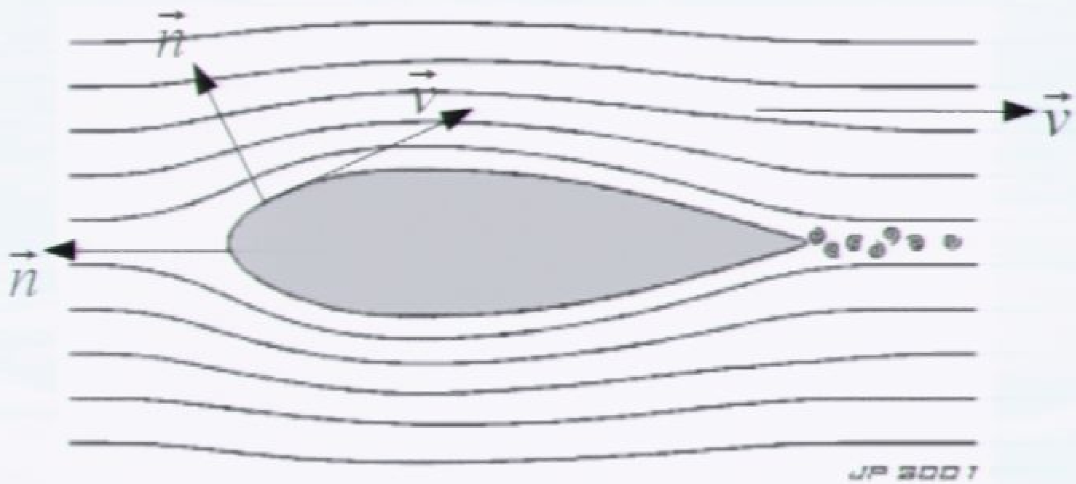

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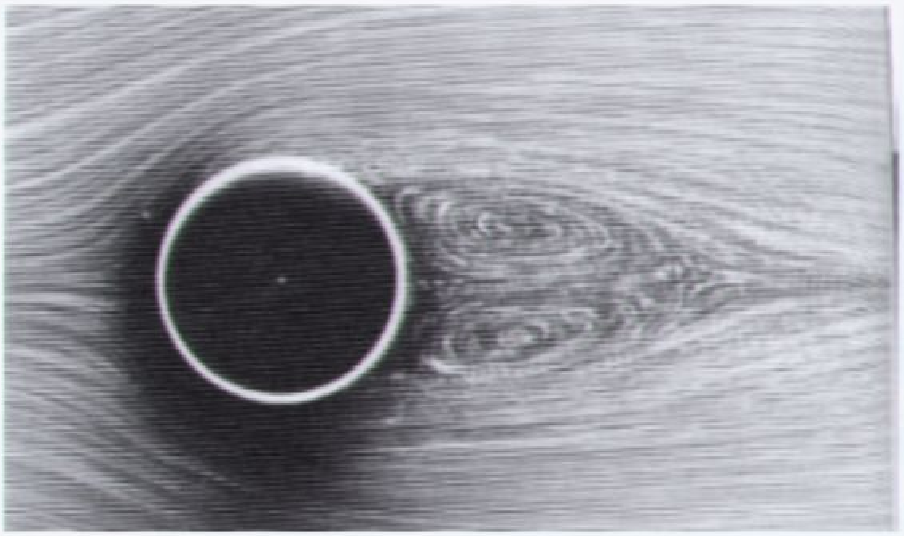

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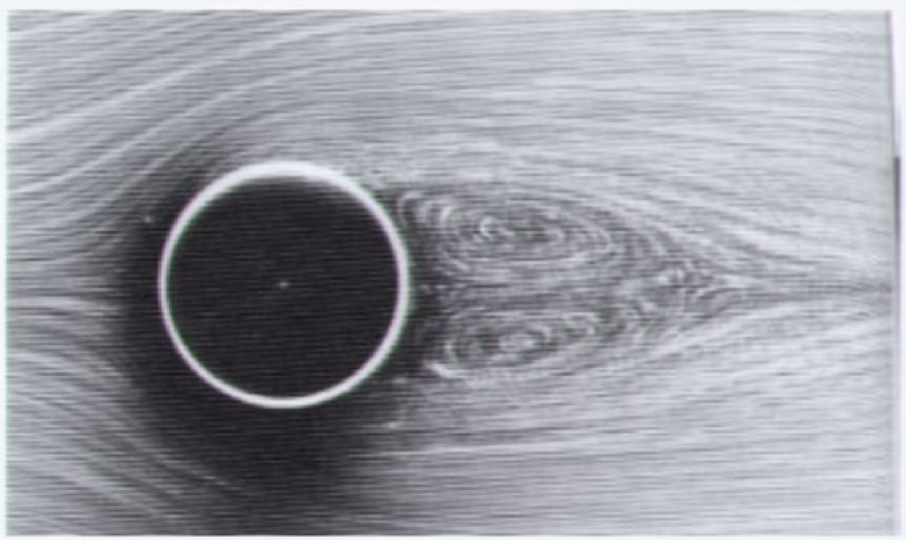

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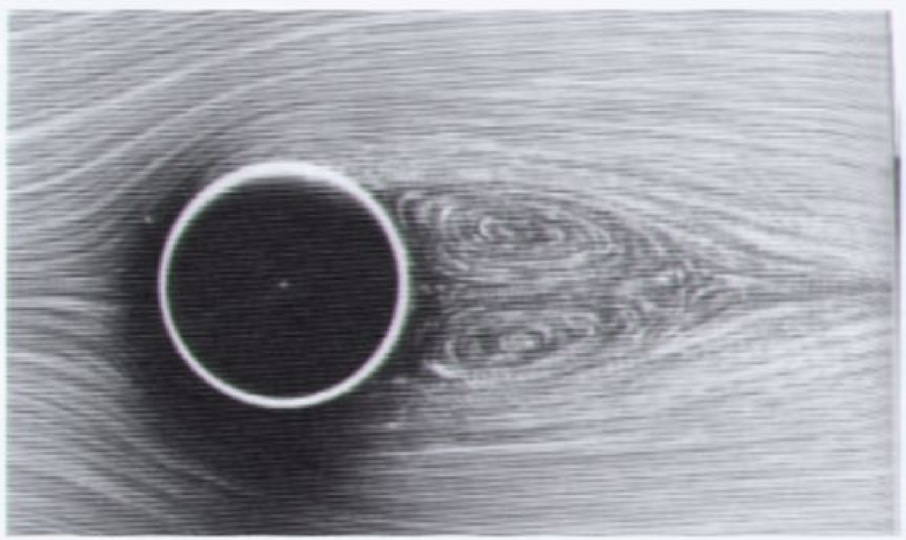

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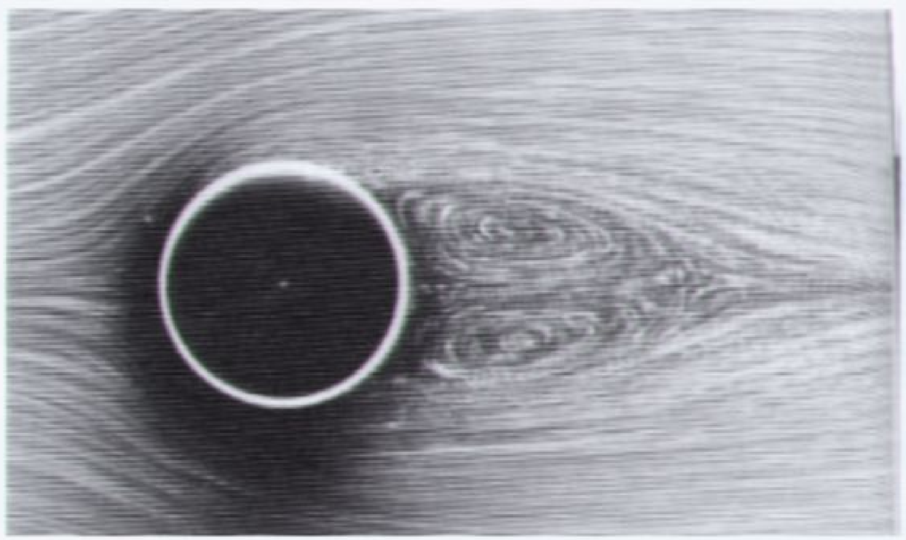

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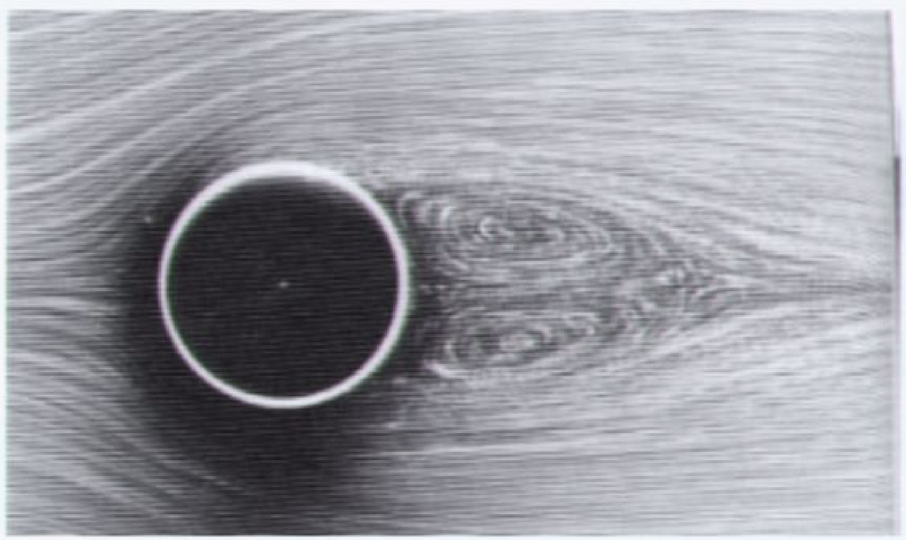

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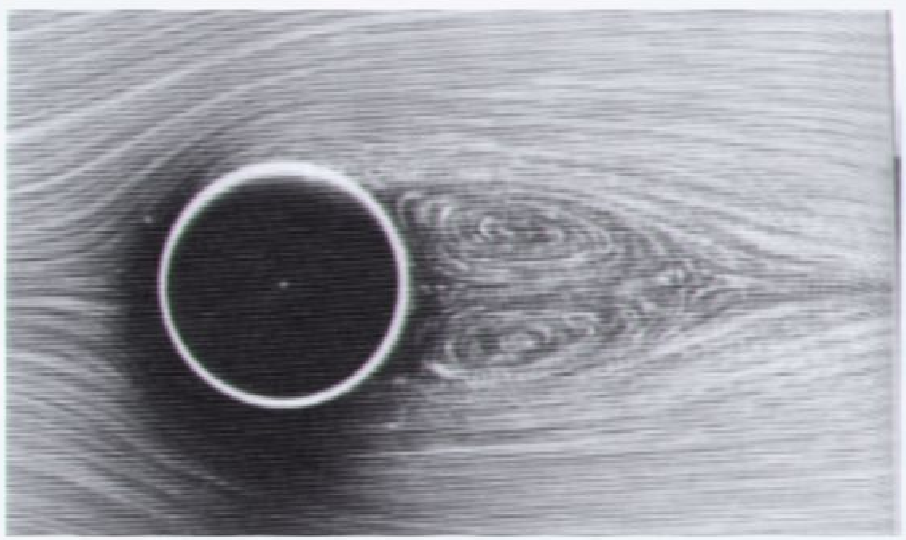

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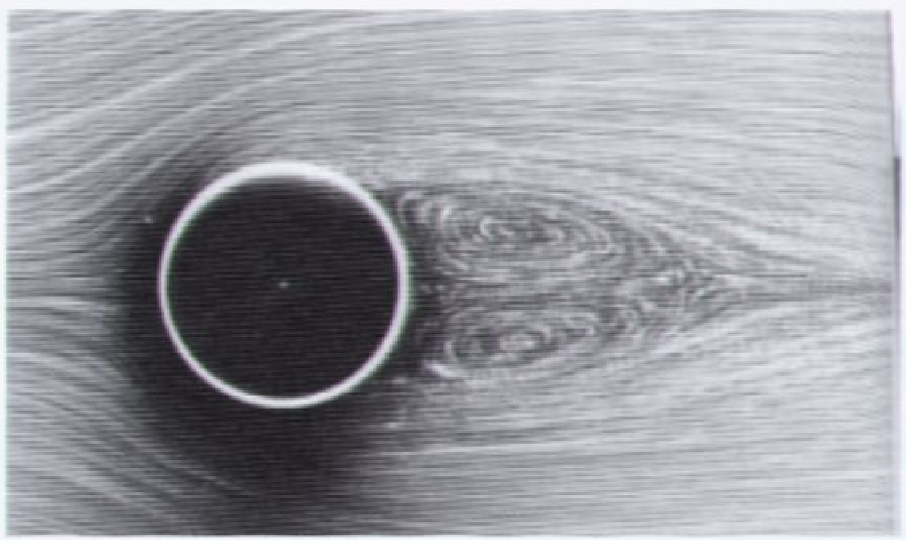

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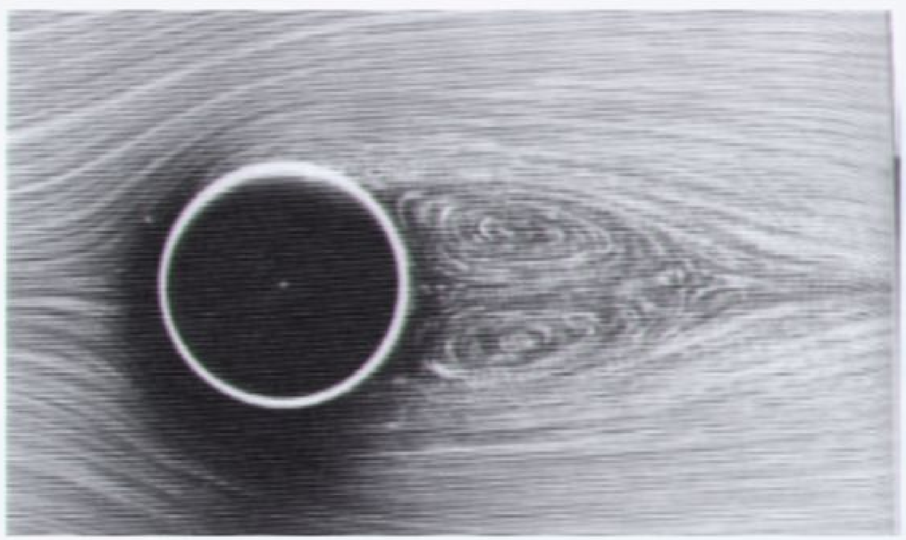

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This results in two different sources of drag:

- Skin friction;
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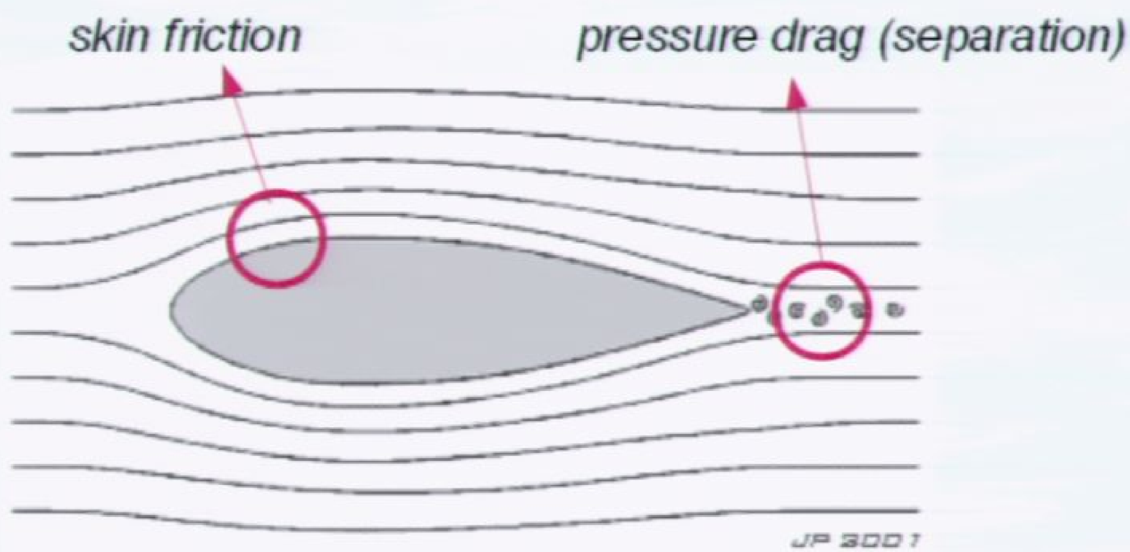

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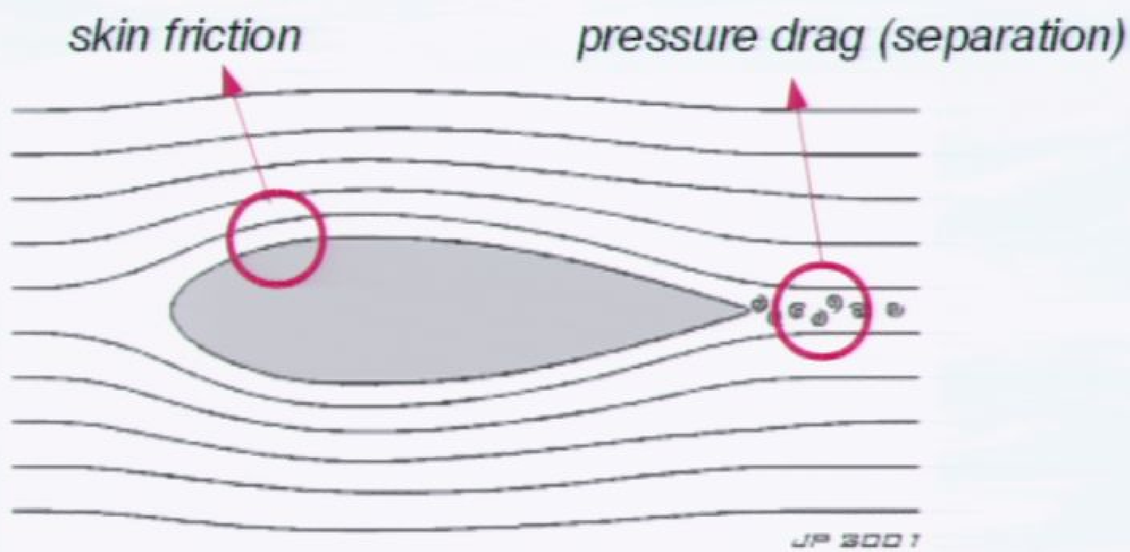

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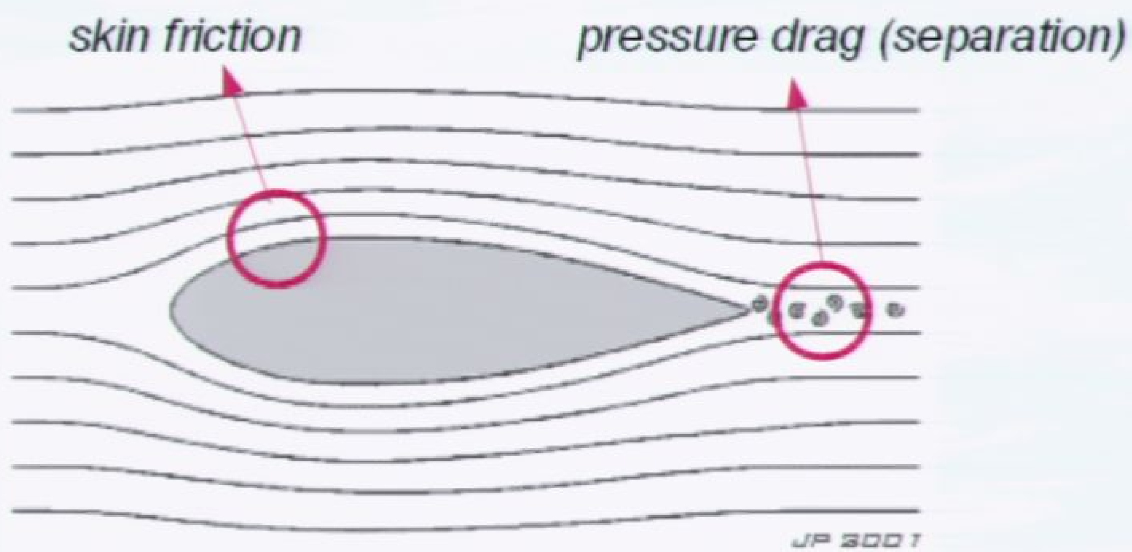

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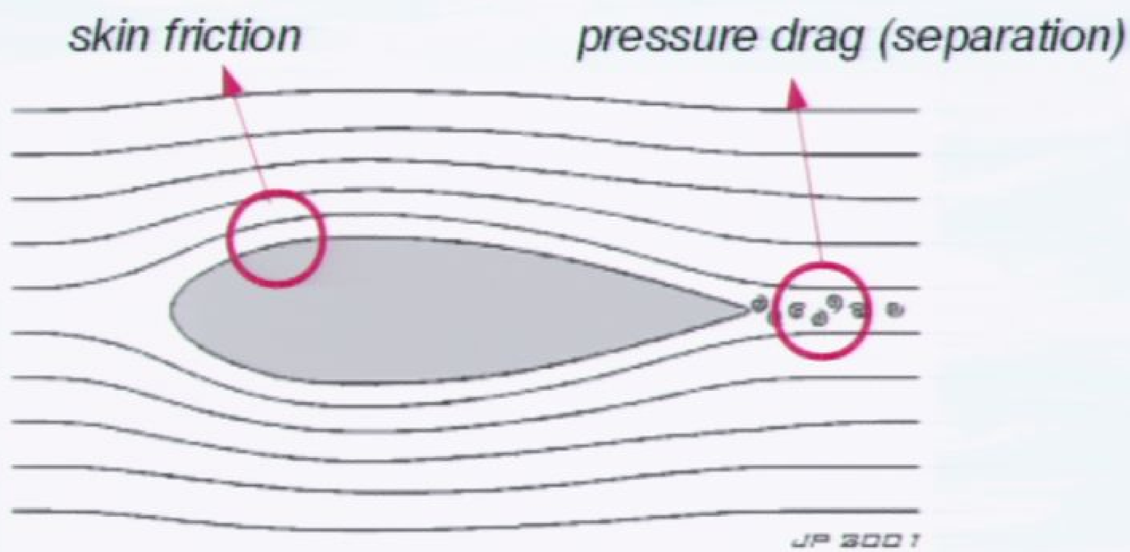

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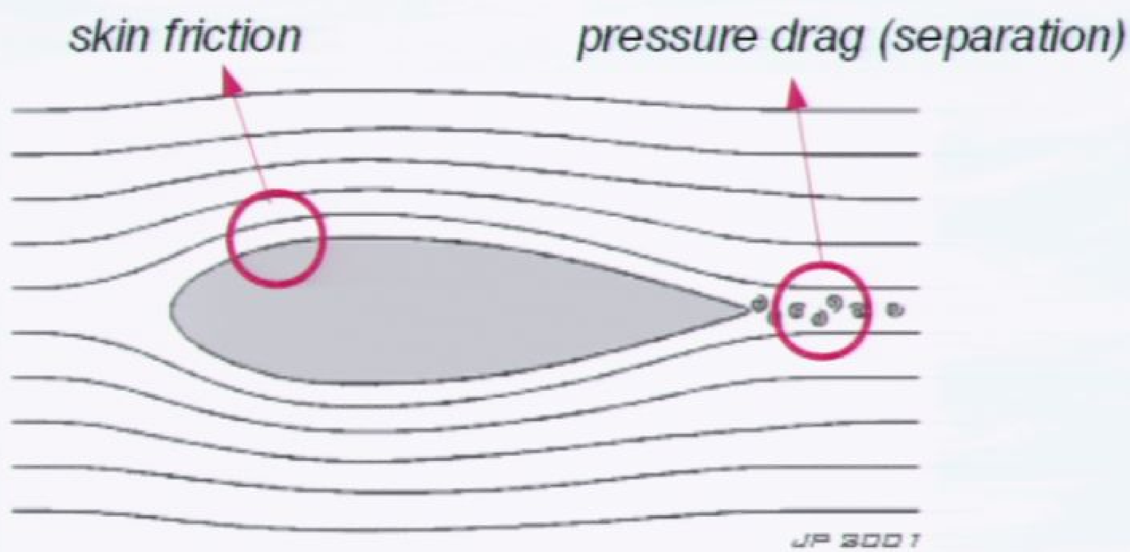

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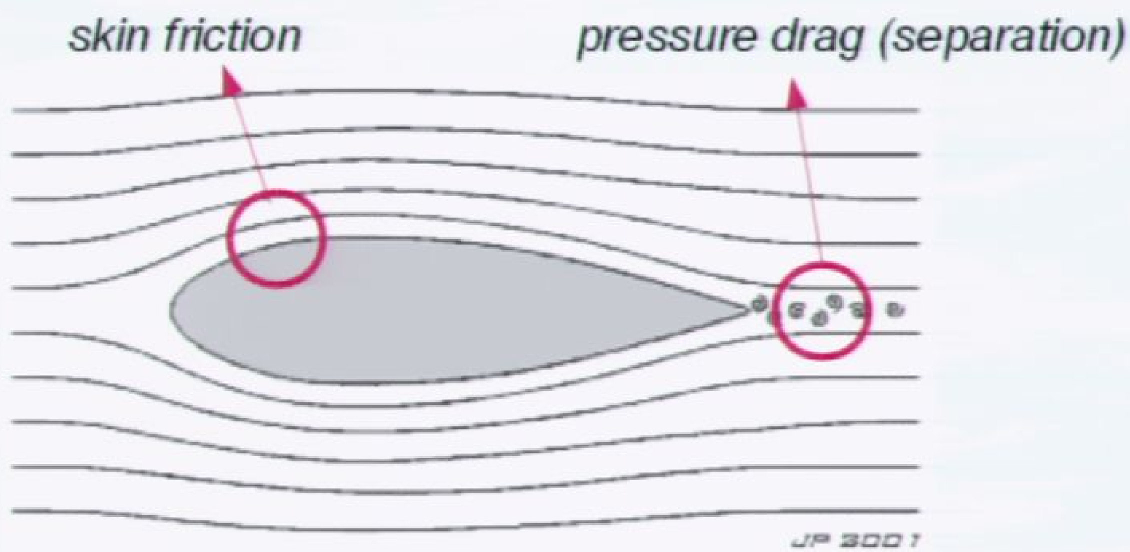

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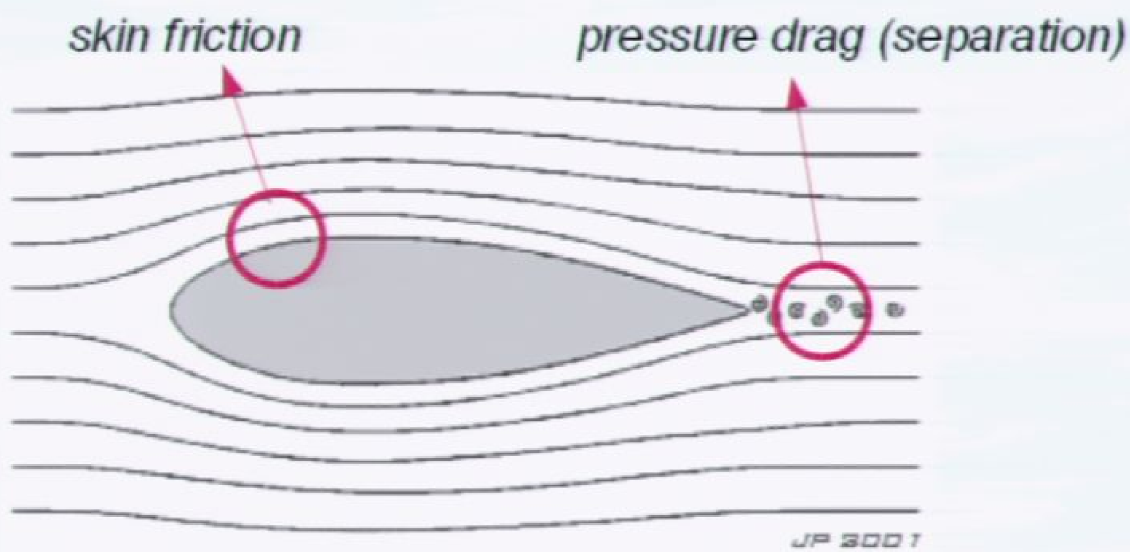

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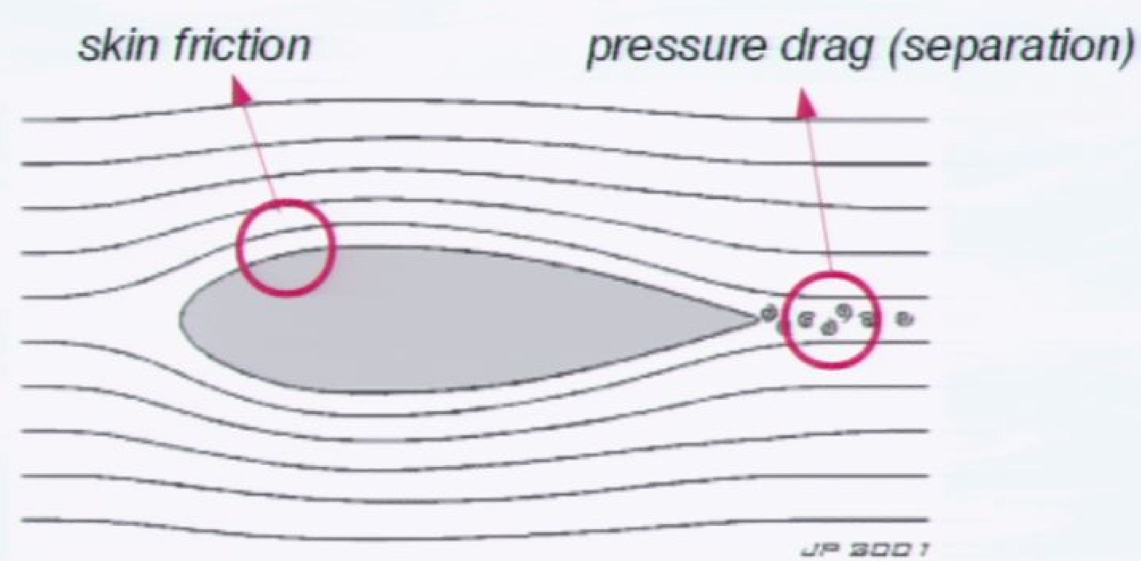

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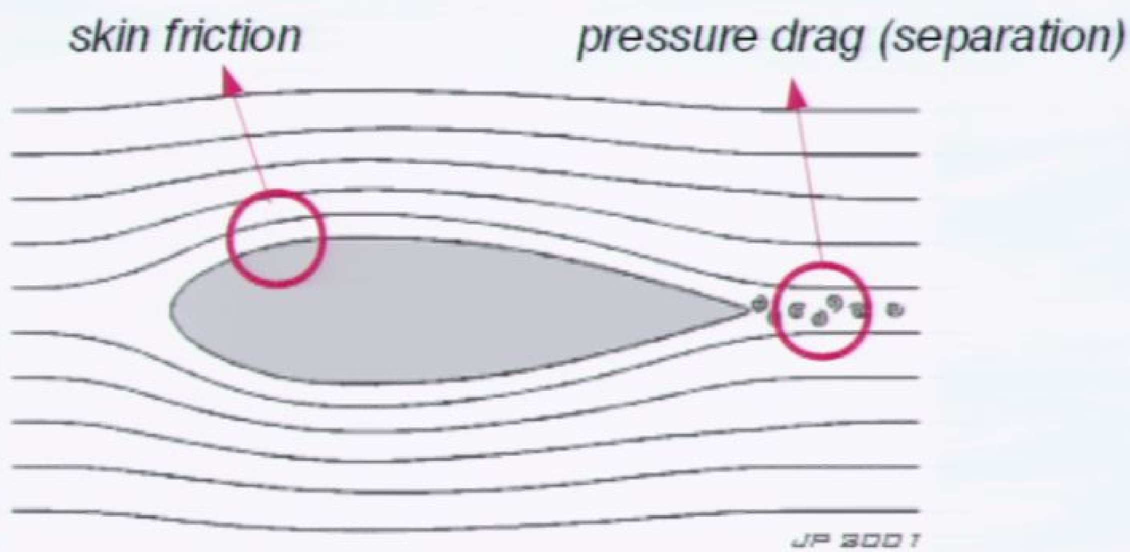

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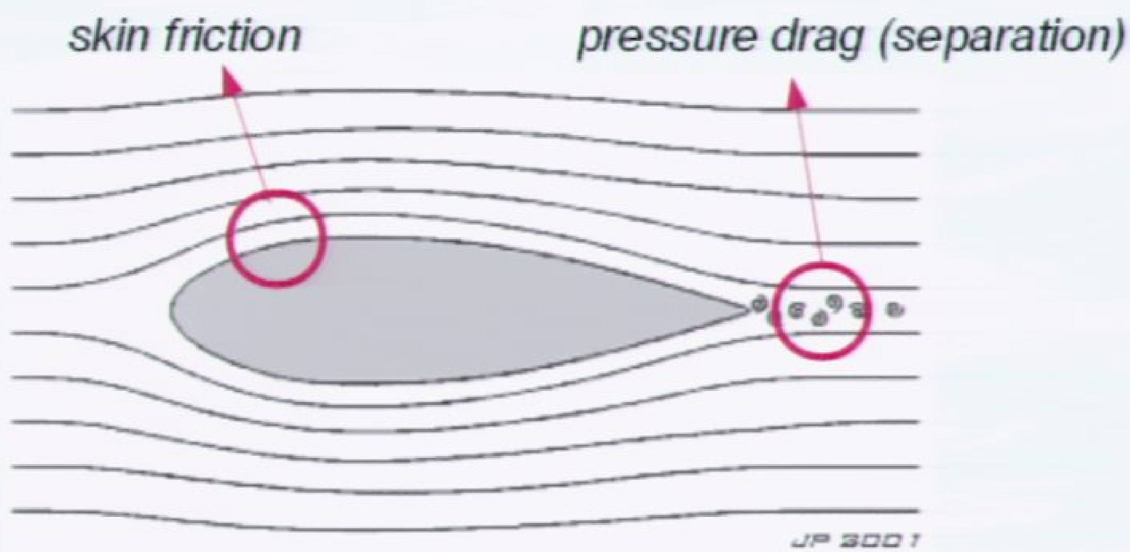

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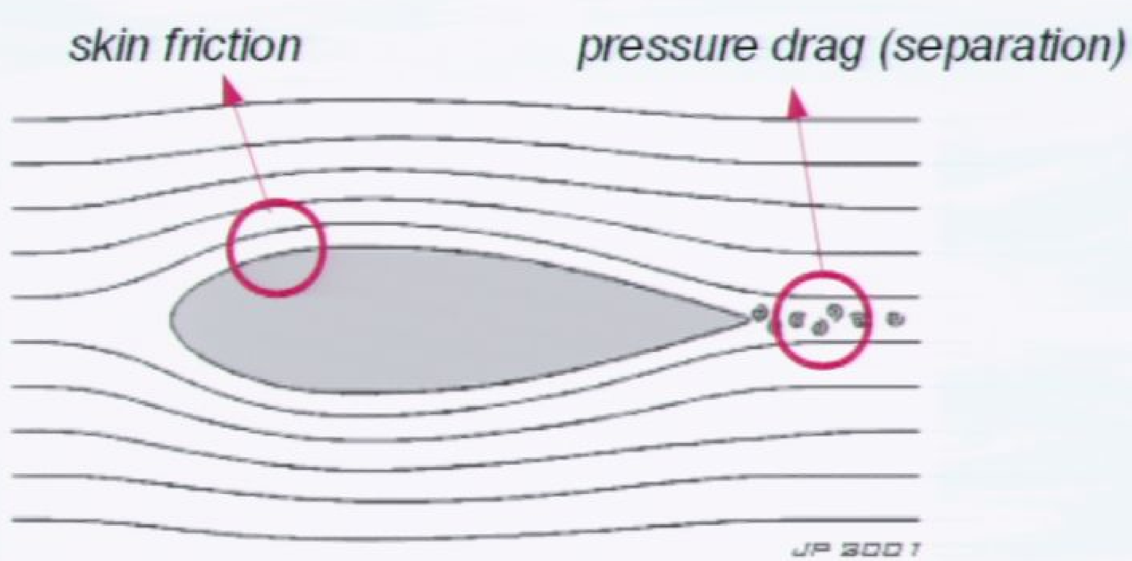

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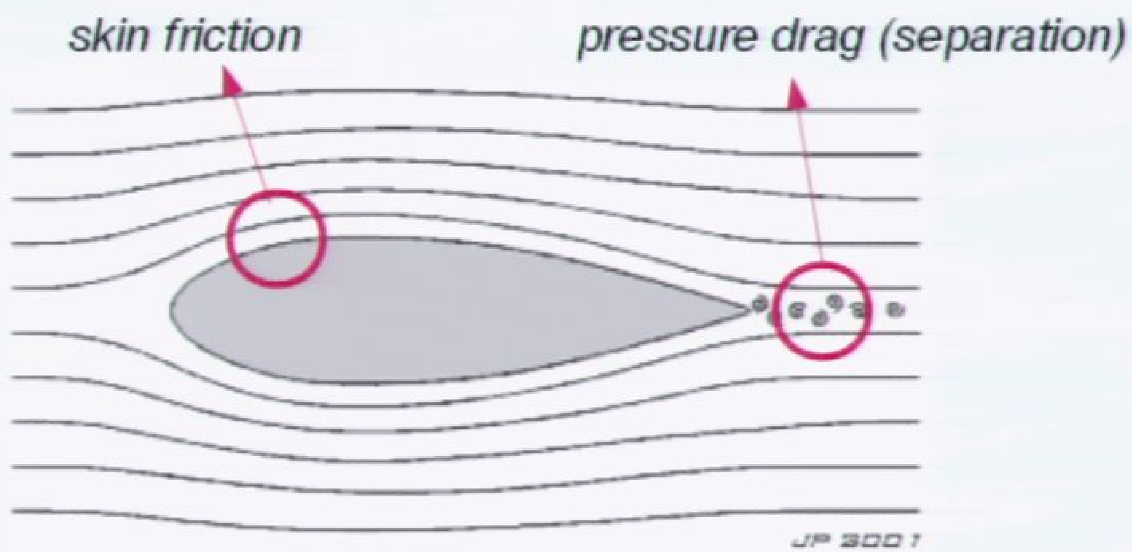

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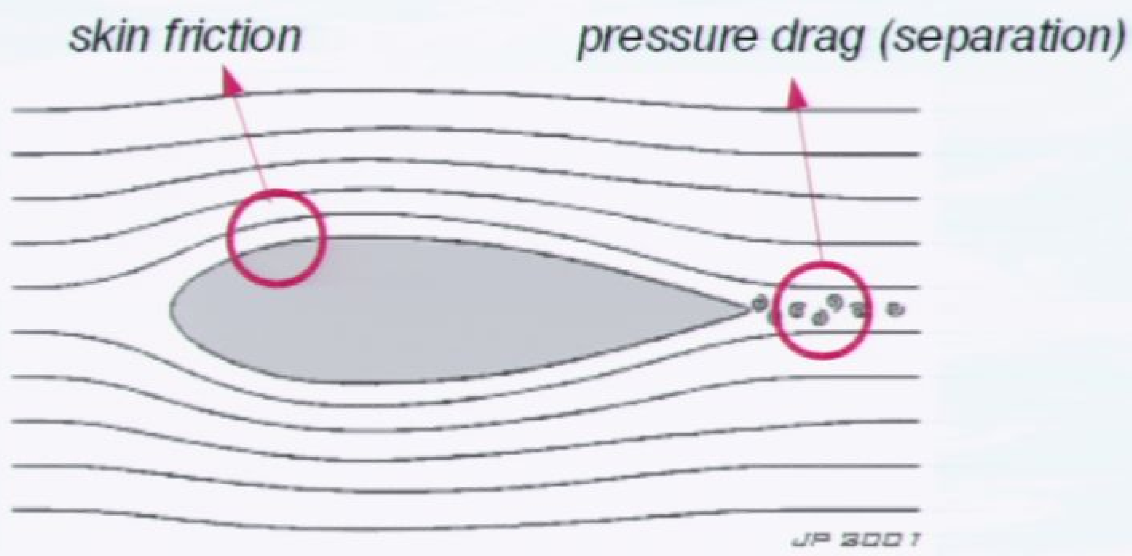

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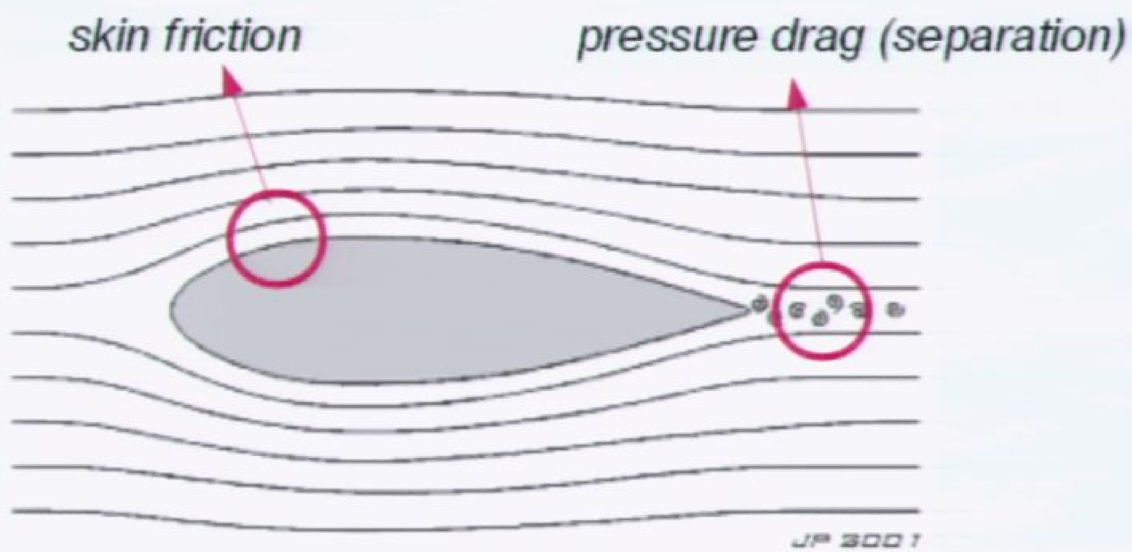

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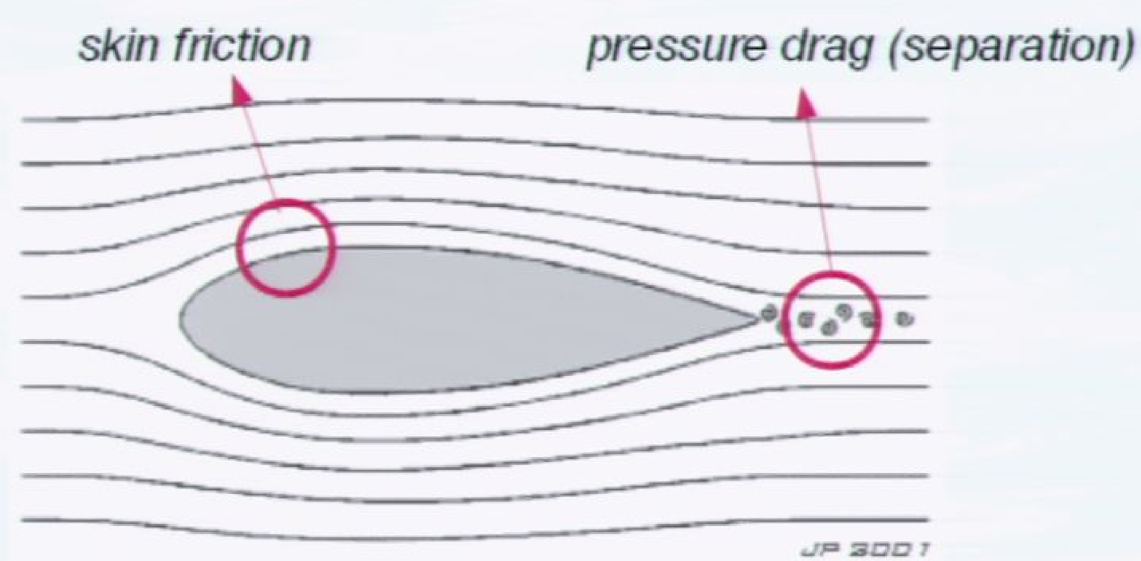

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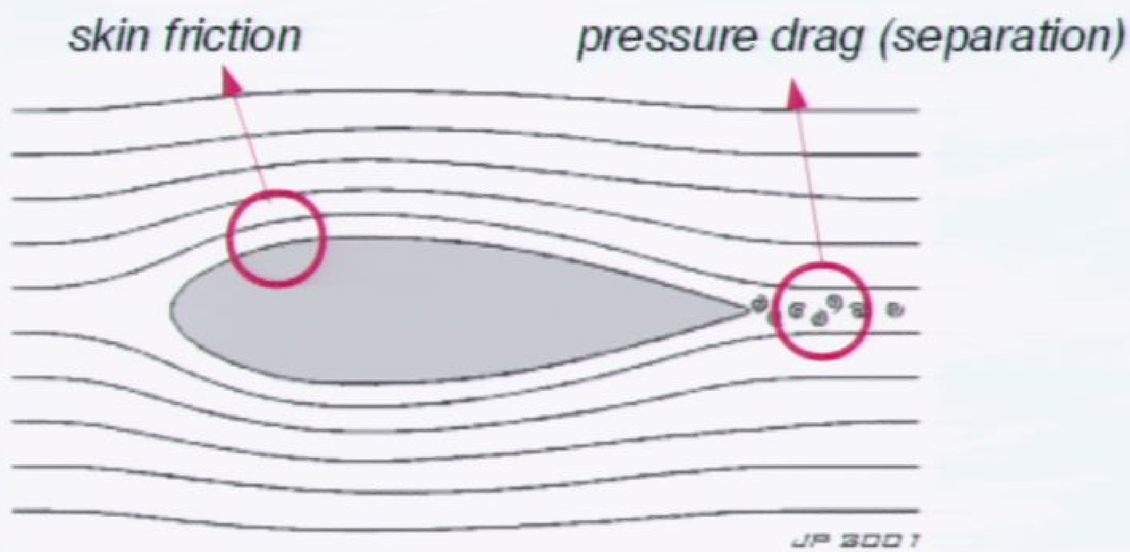

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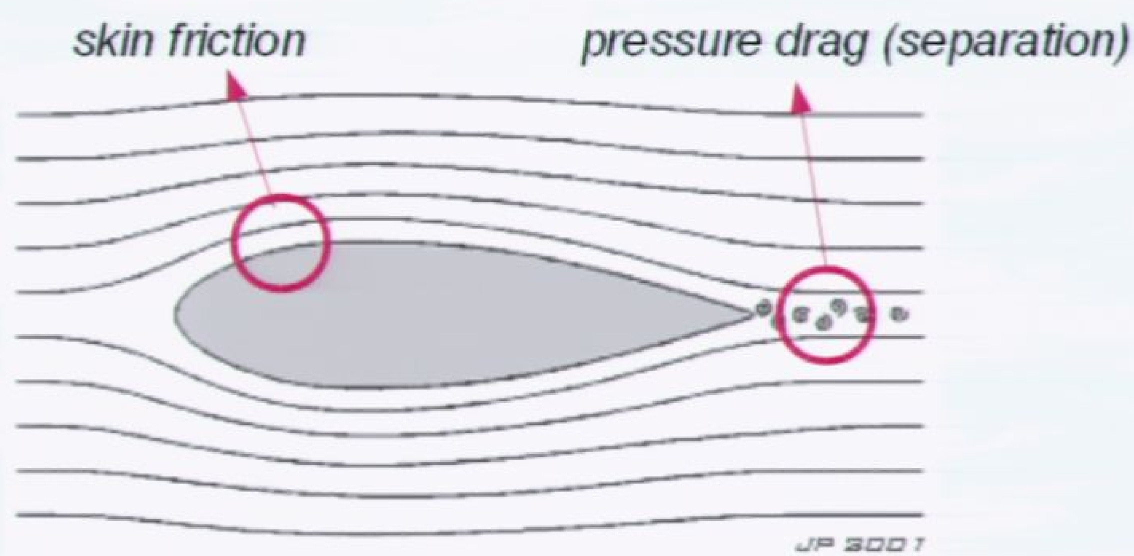

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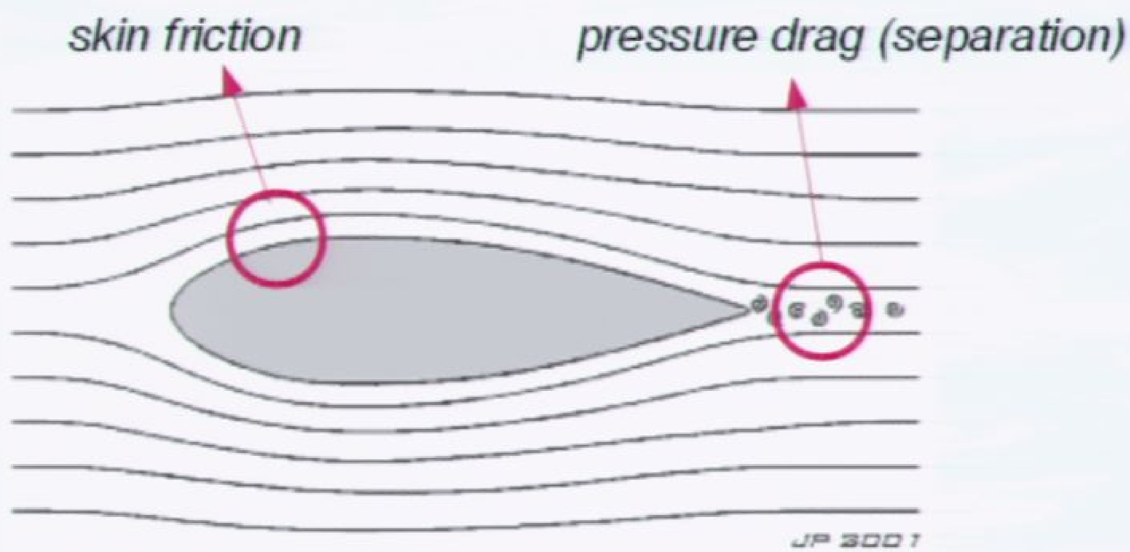

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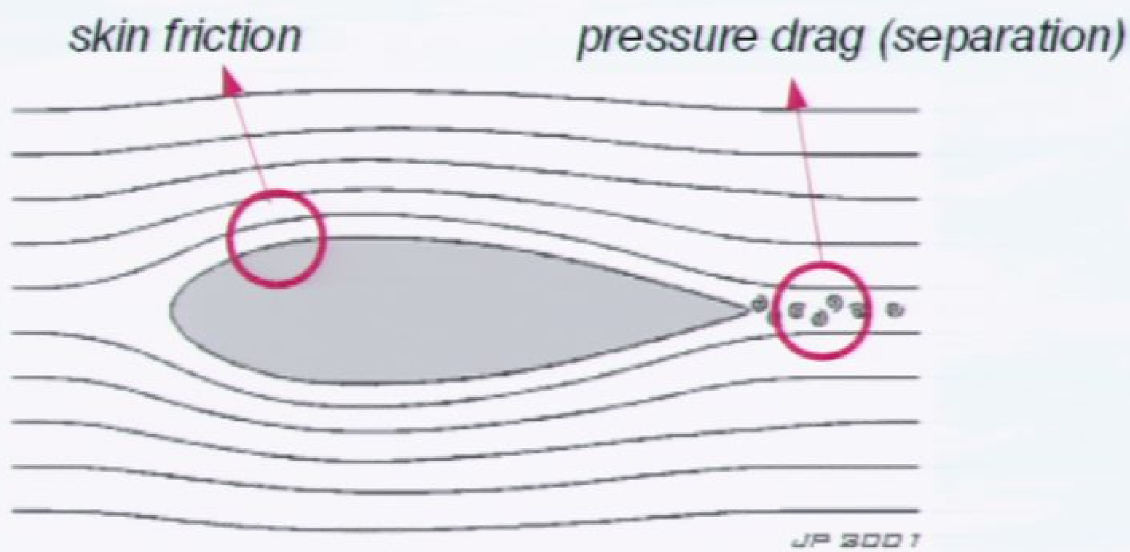

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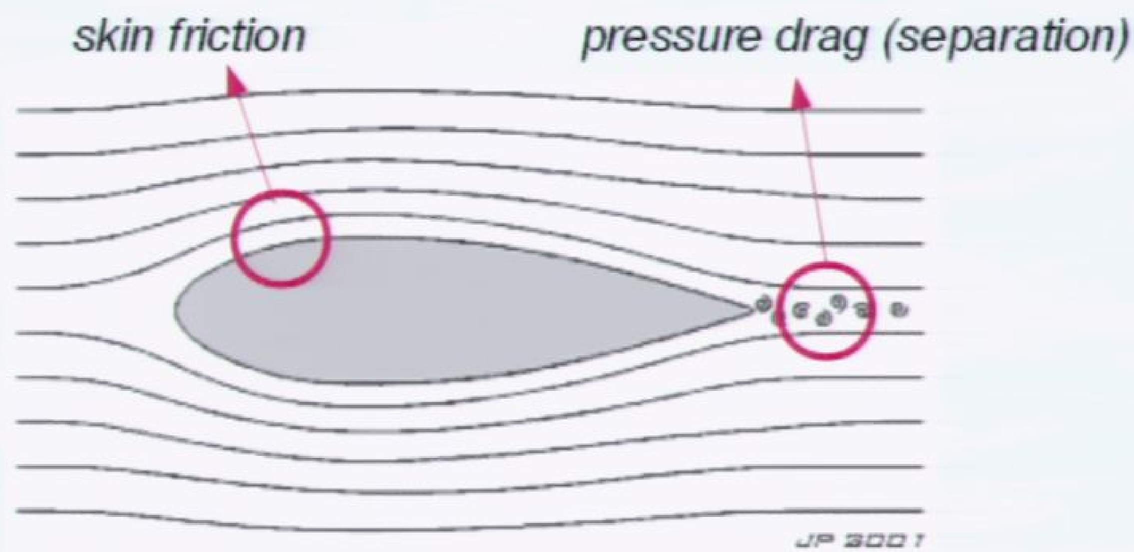

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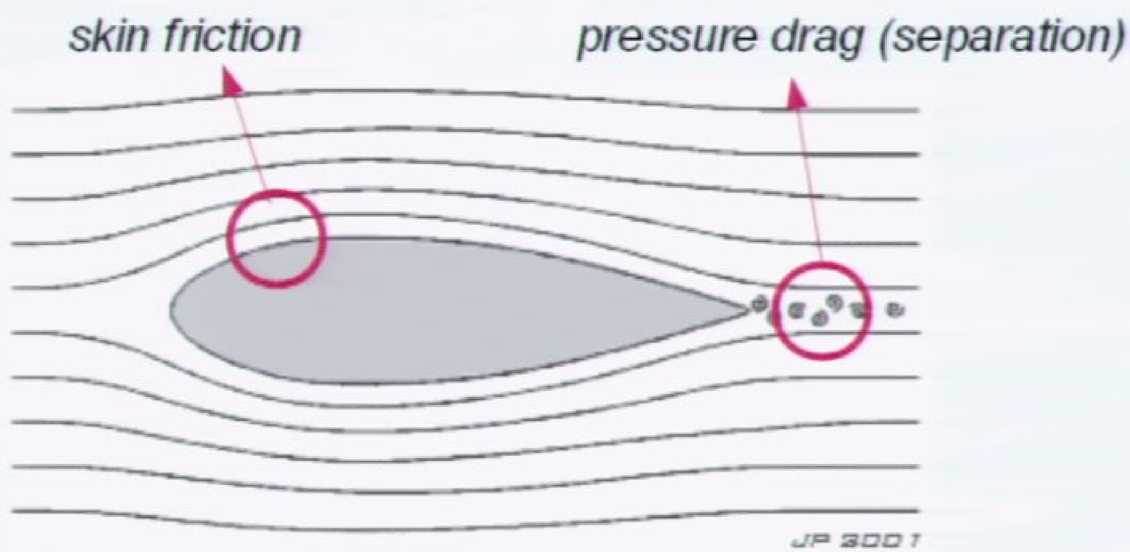

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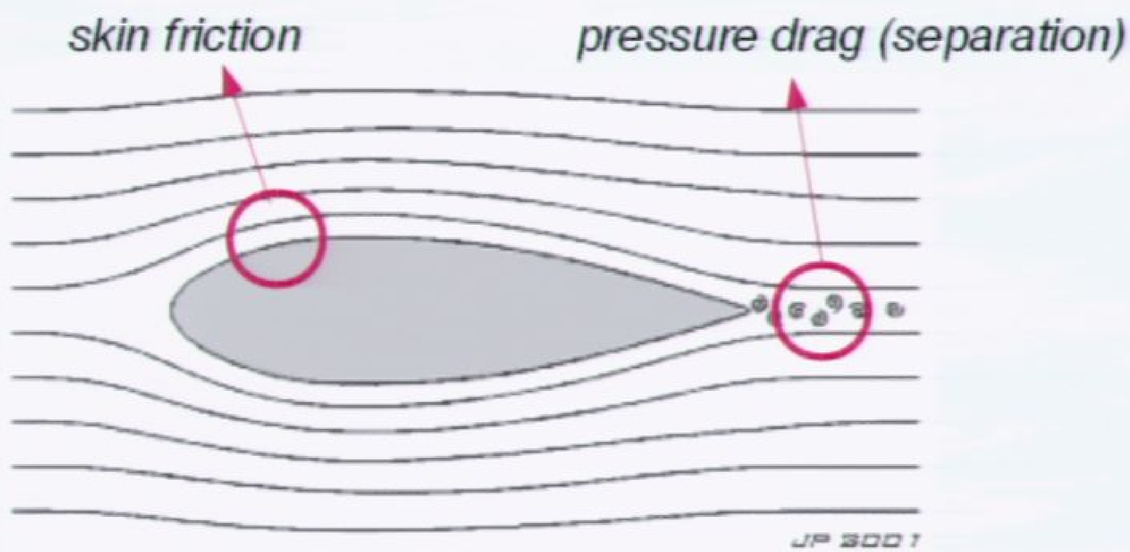

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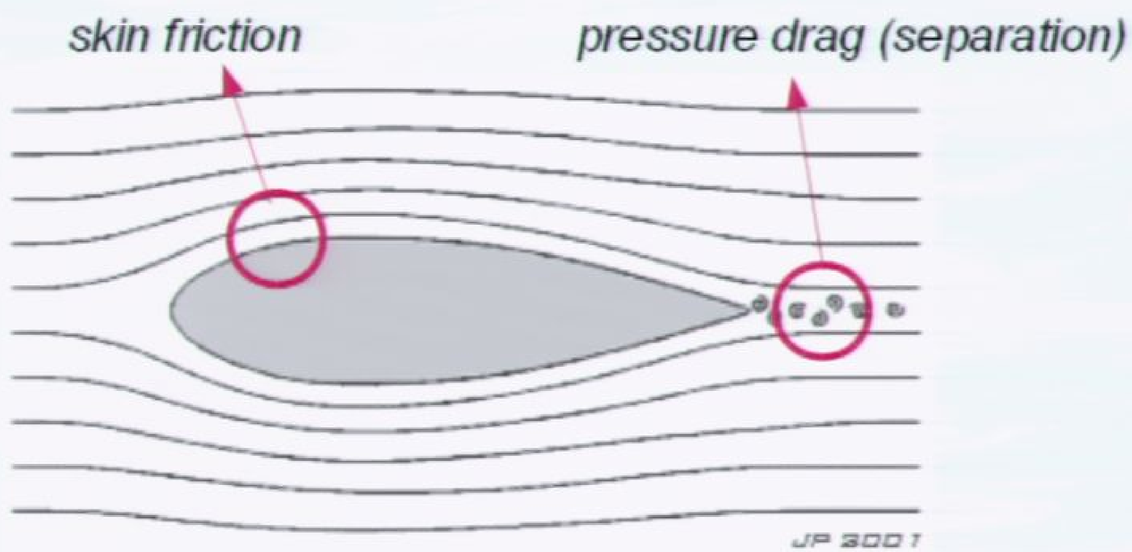

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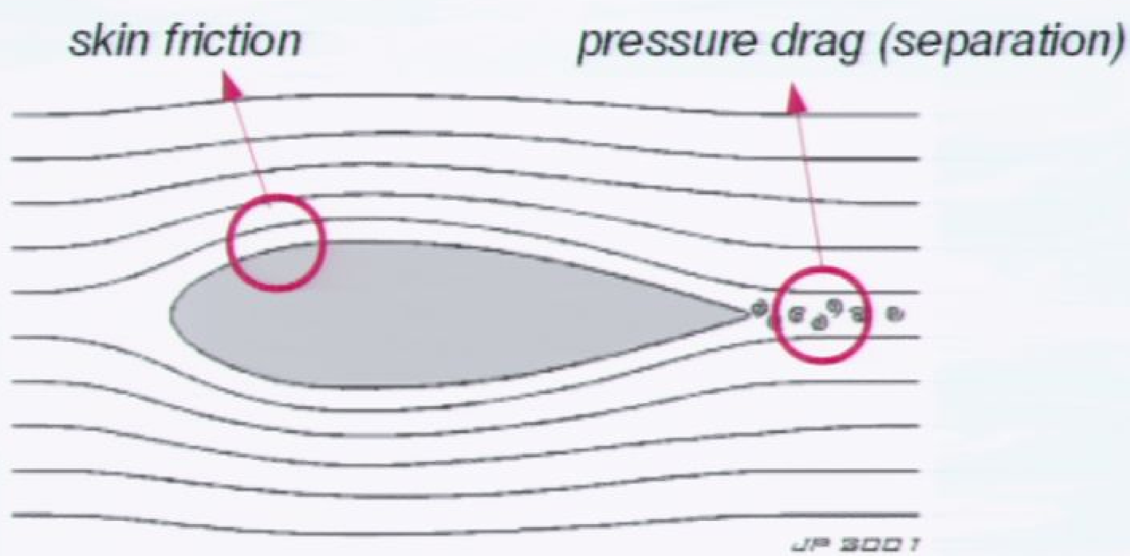

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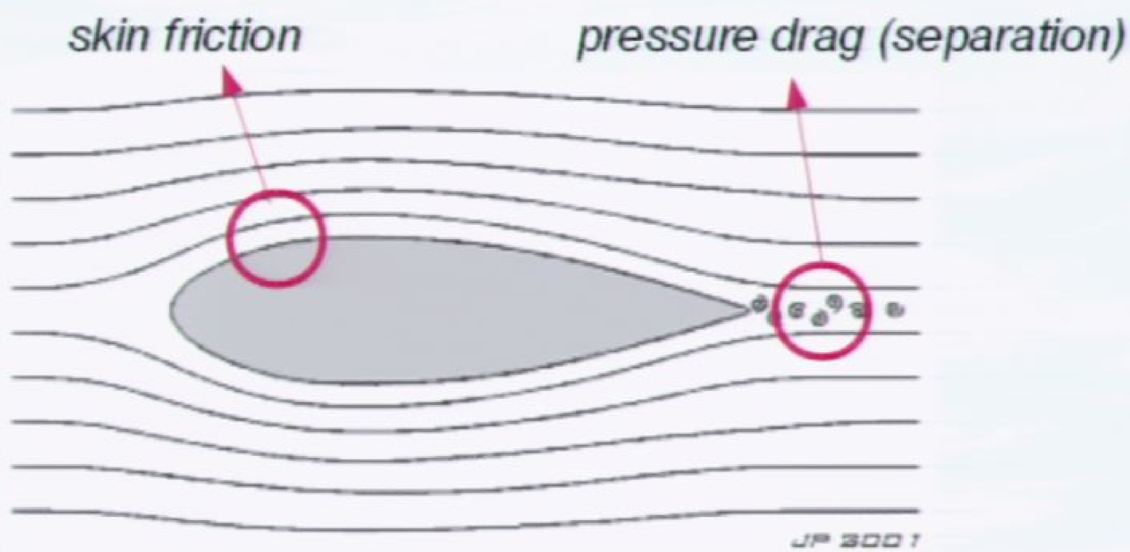

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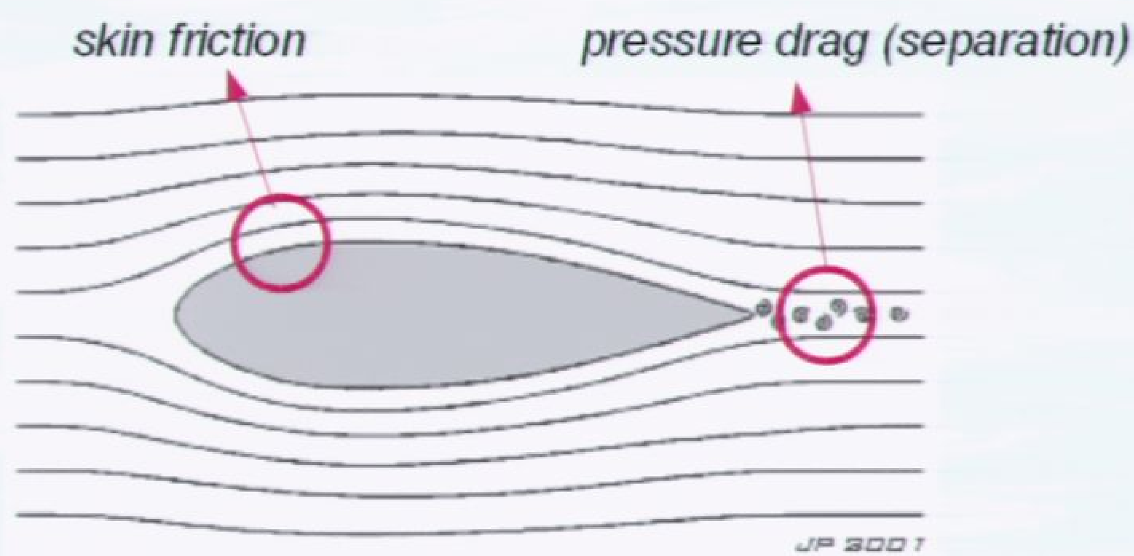

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Principle: In low-viscosity fluids, internal friction is only appreciable in a thin region surrounding the boundaries, the *boundary layer.*

This results in two different sources of drag:

- Skin friction;
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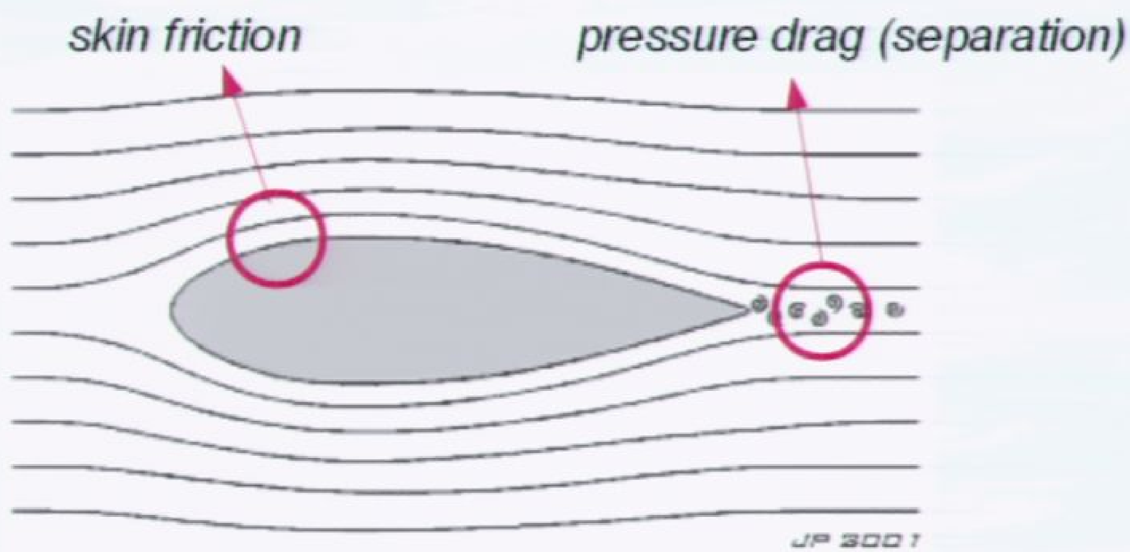

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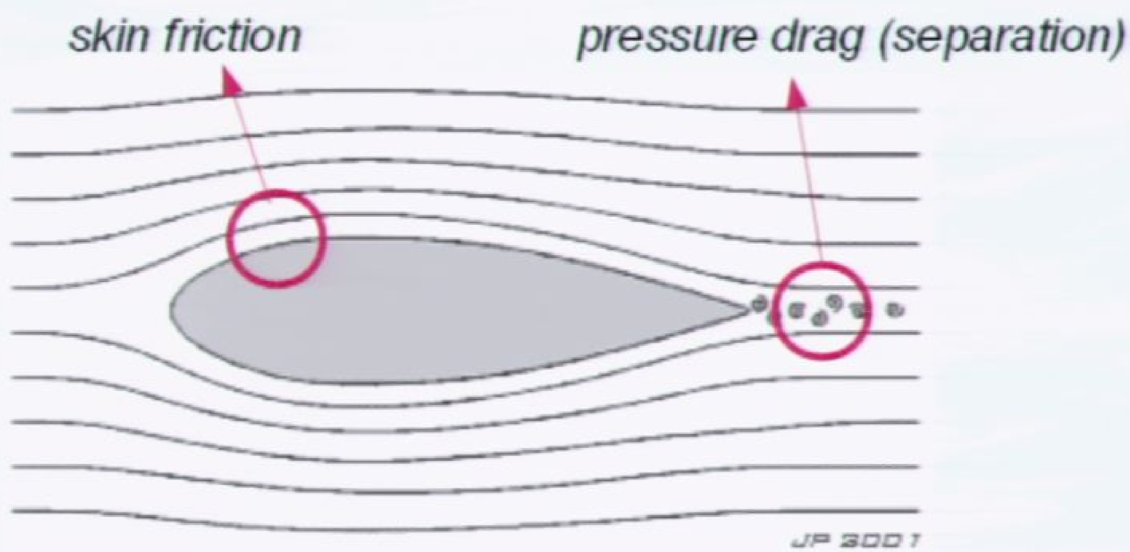

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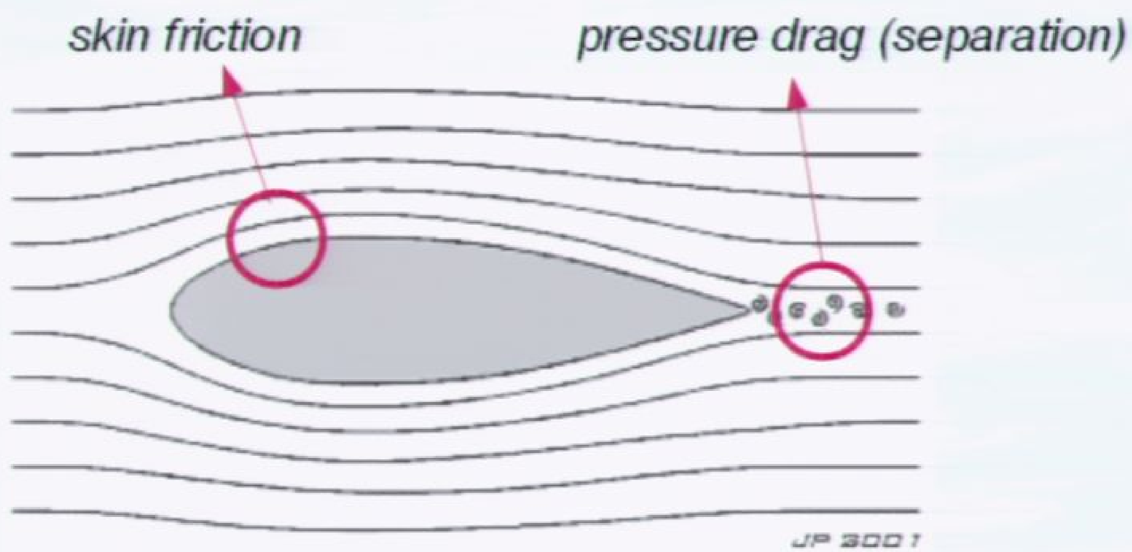

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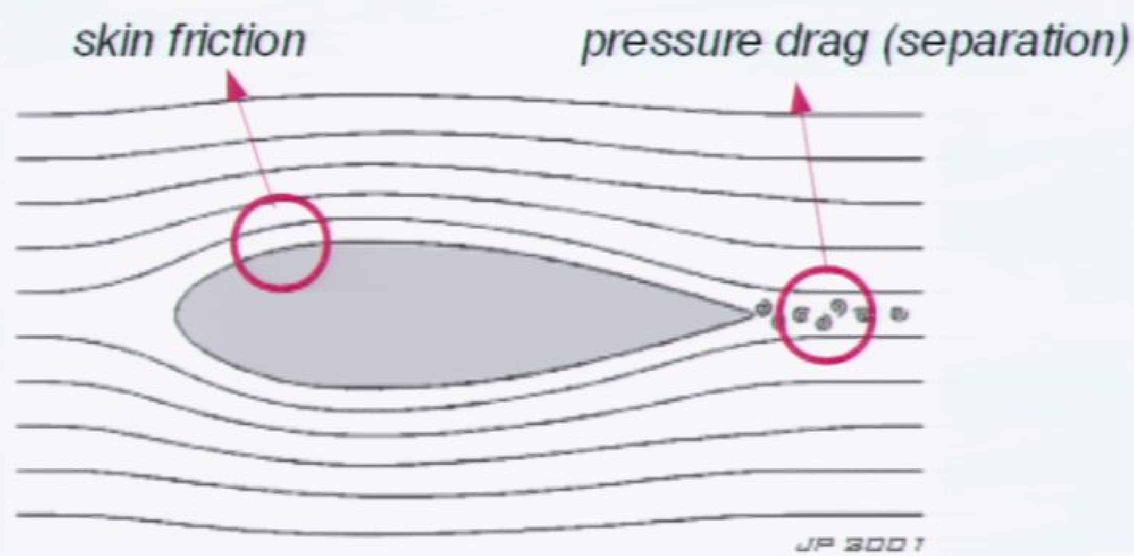

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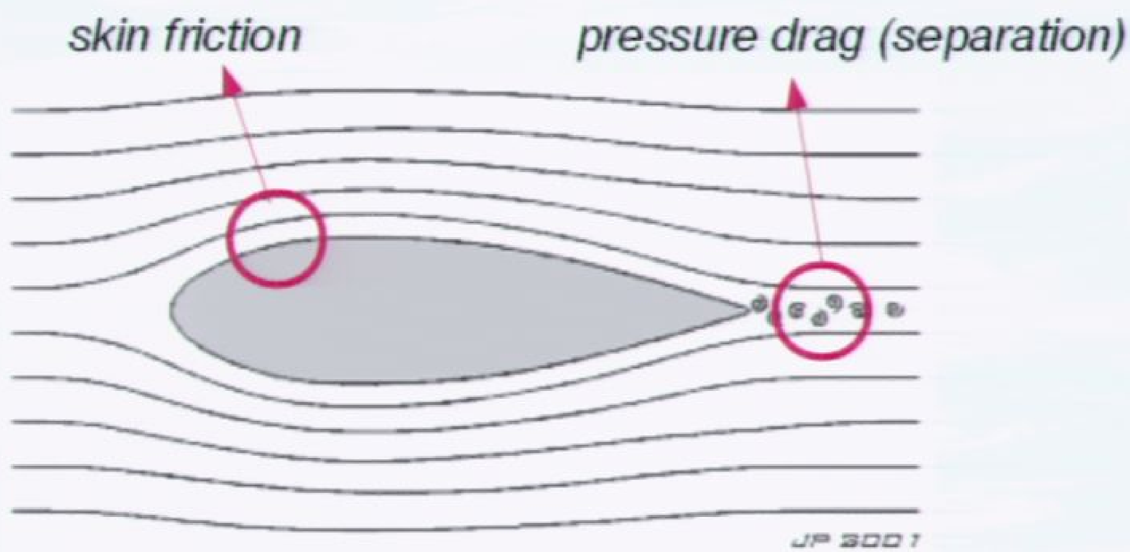

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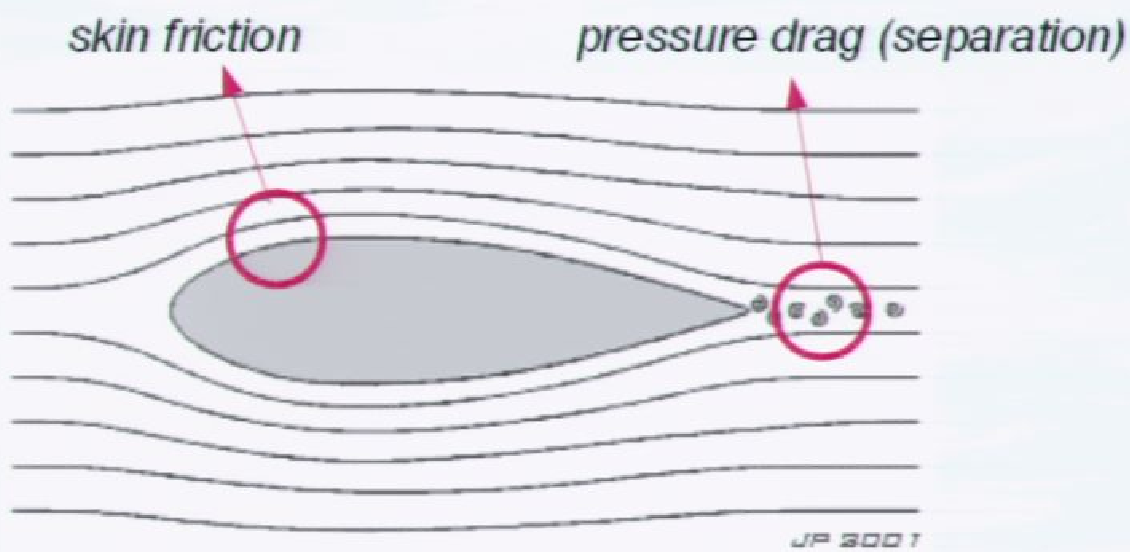

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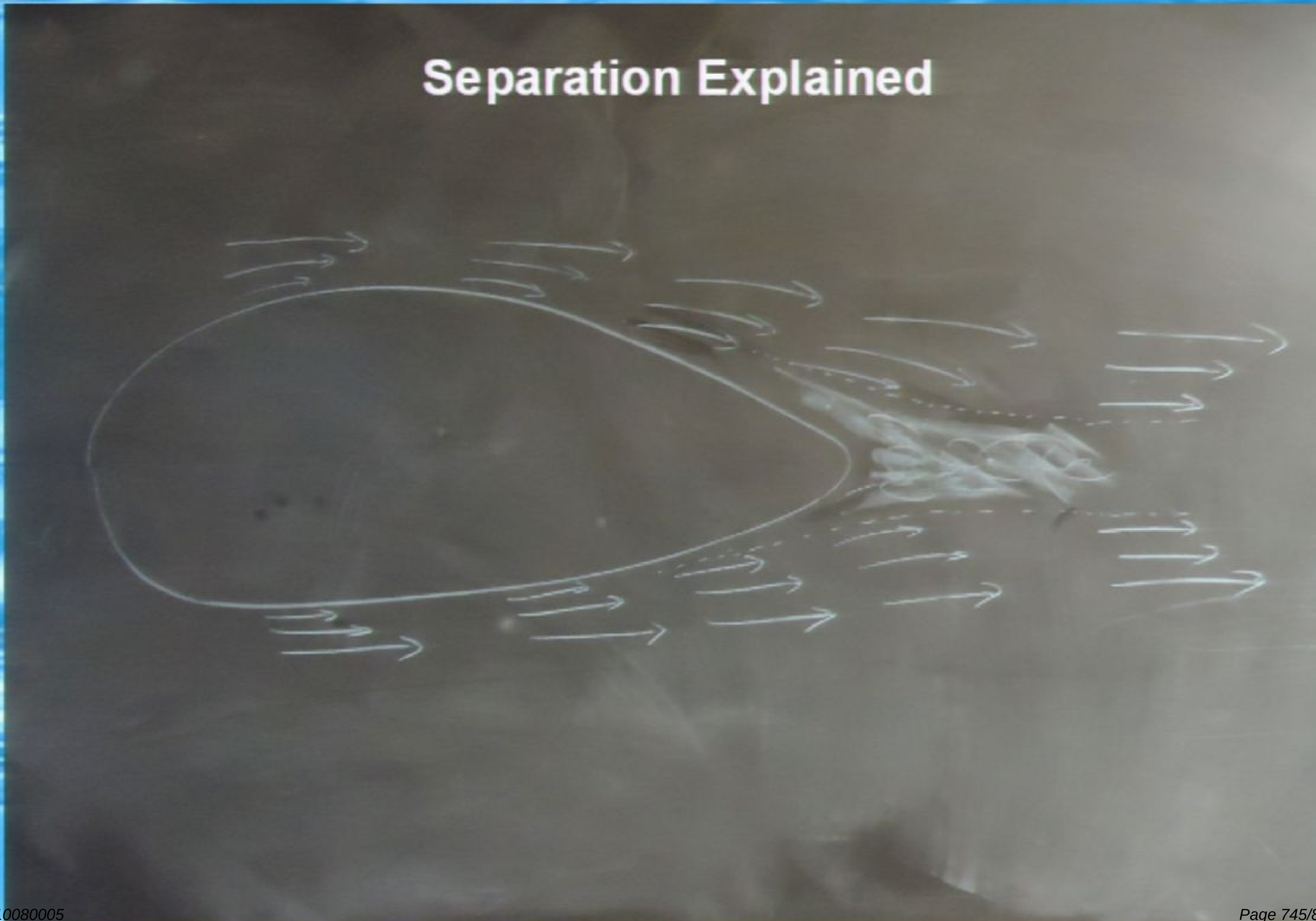

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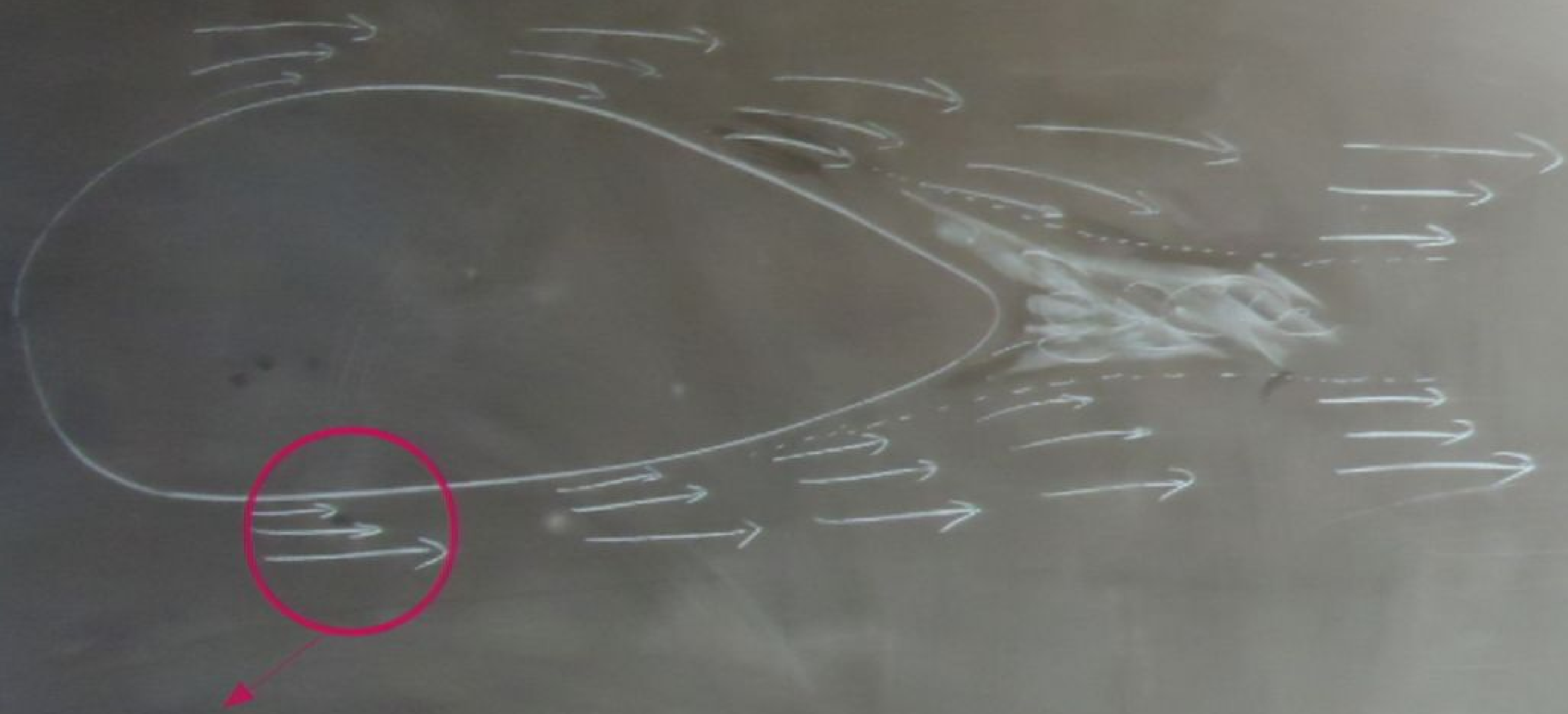
Separation Explained



Boundary layer is slowed down because of skin friction...

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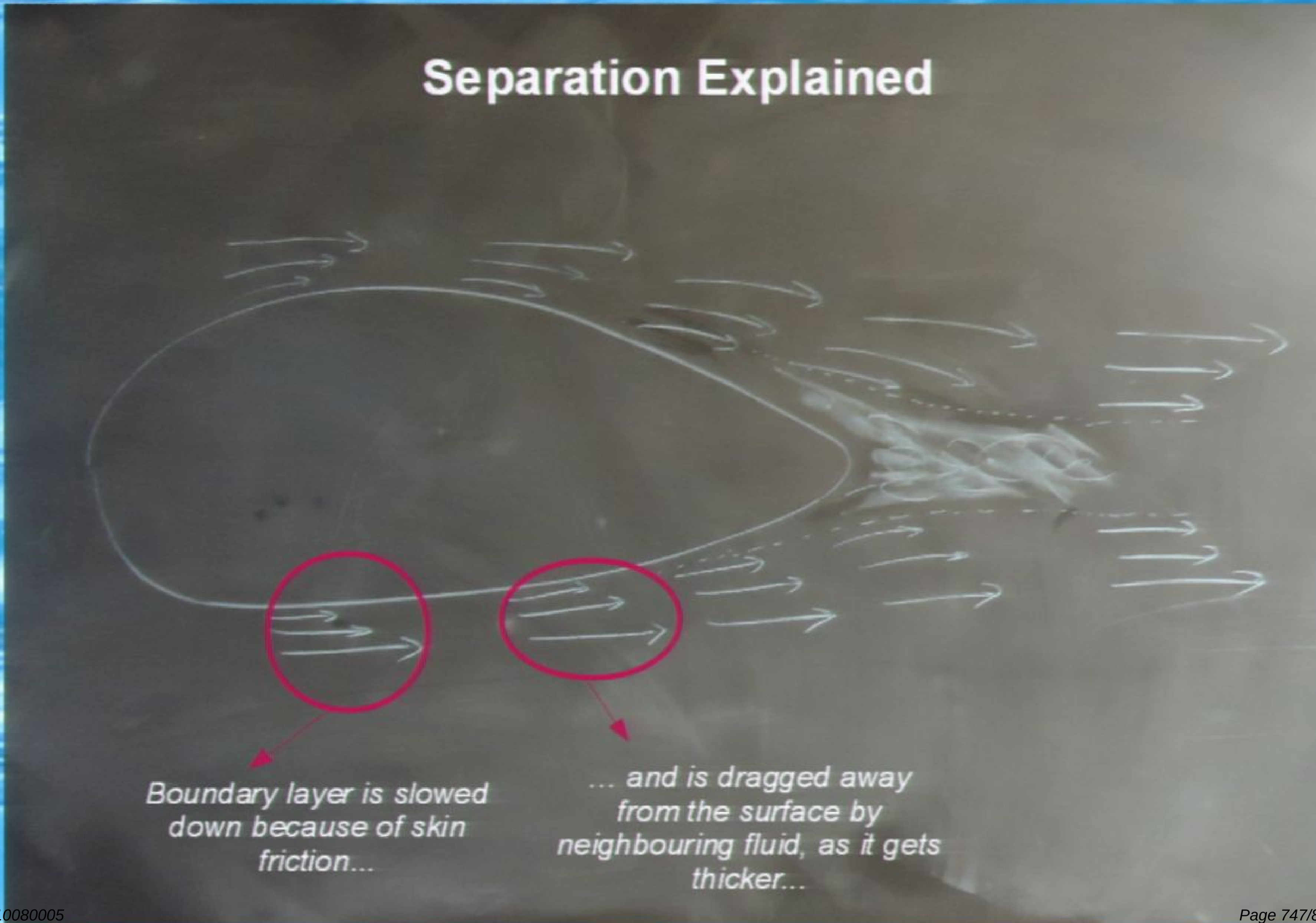

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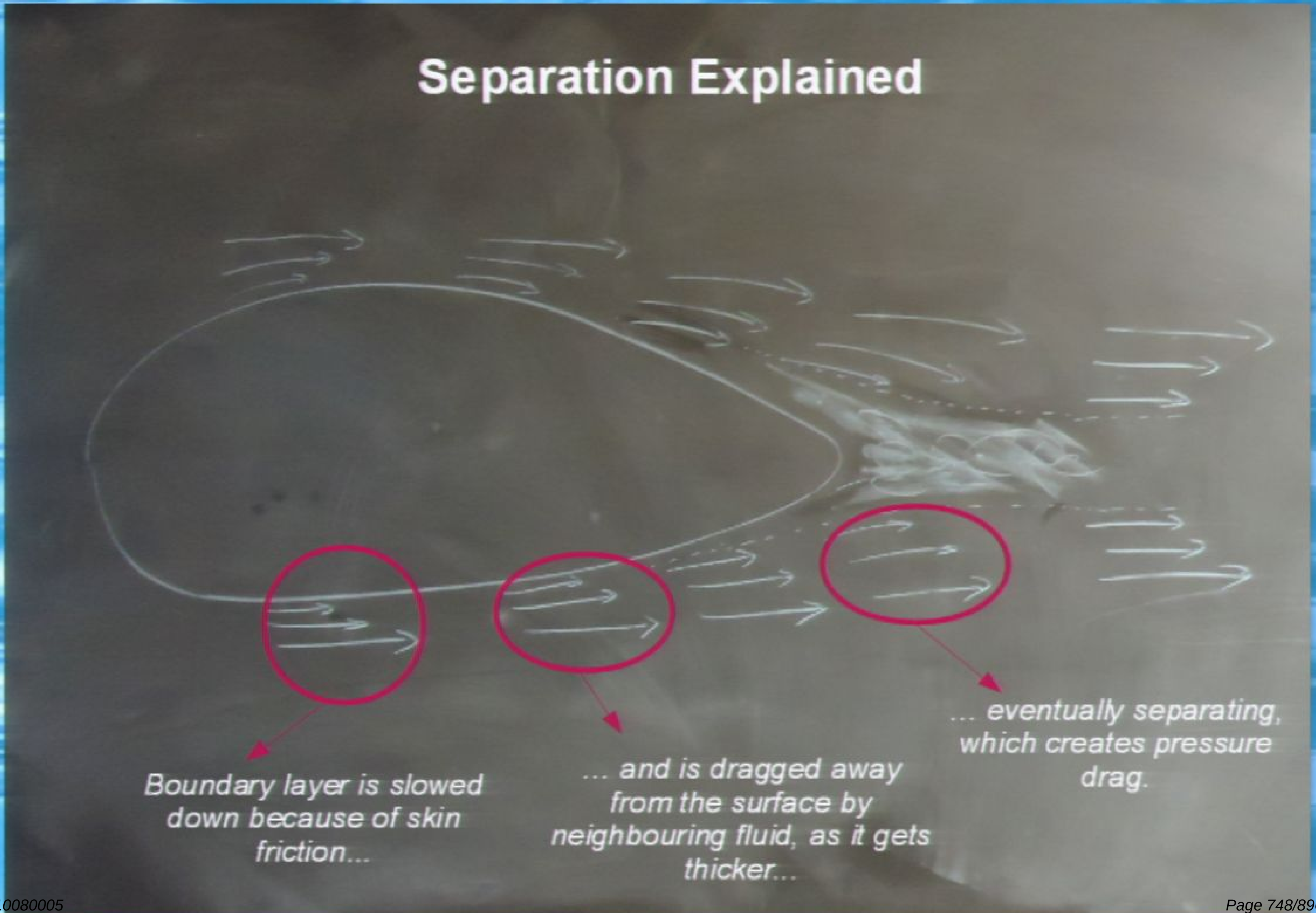

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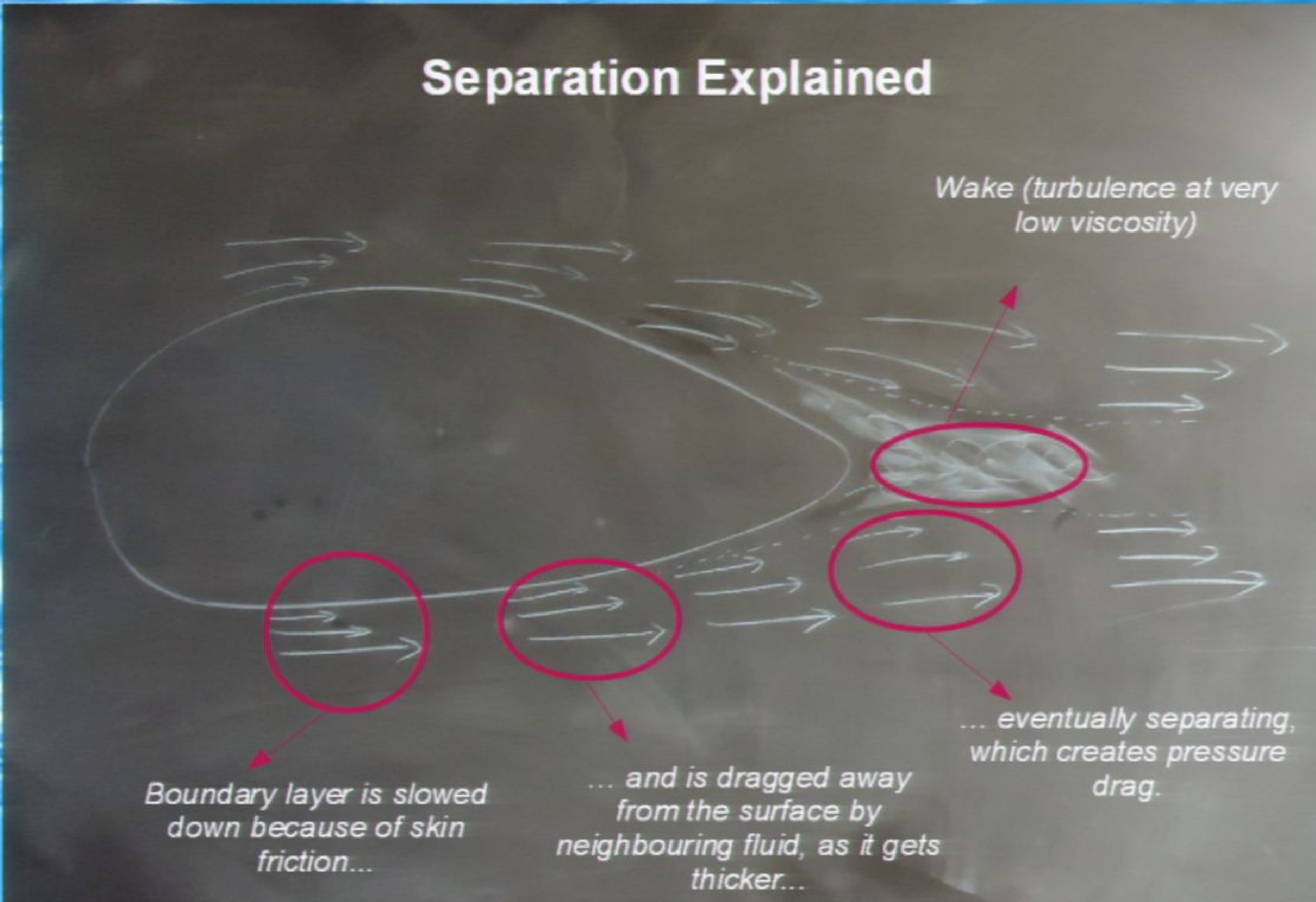

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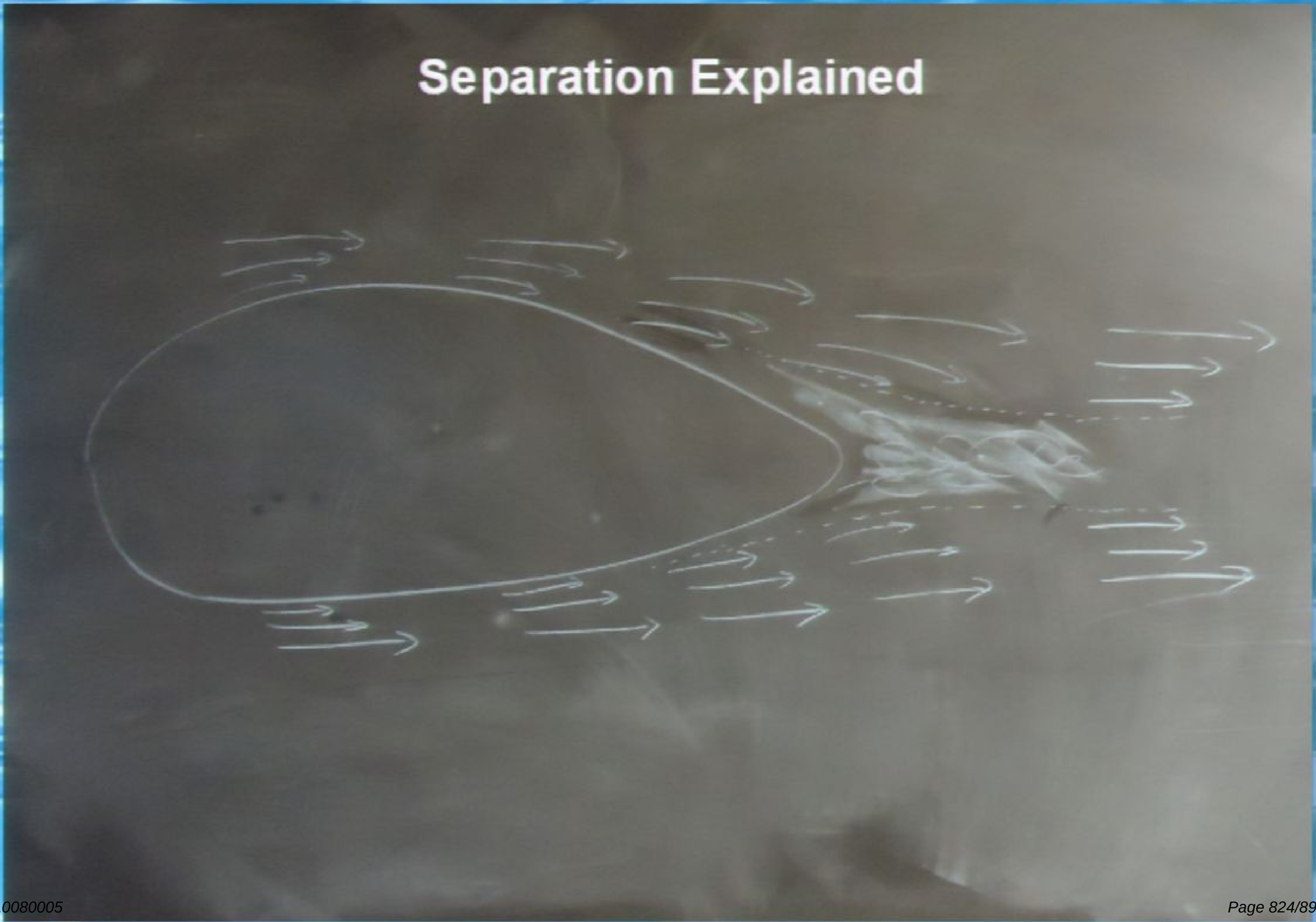
2. Qualitative Description of Drag



1. Outline of the physical problem

- Consider the flow of a viscous fluid past an obstacle (equivalent to the swim of a body in a previously static fluid):

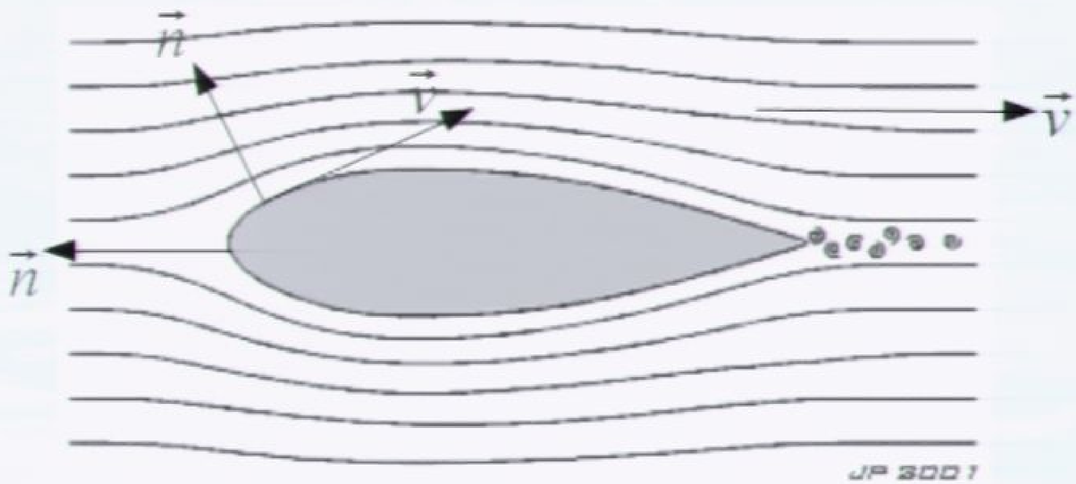


Image: Coilgun Systems website

- For simplicity, consider a 2D flow
- Velocity is constant far from the body, $\vec{v} = v\,\vec{e}_x$
- In the surface, the normal component of velocity vanishes, $\vec{v}\cdot\vec{n} = 0$

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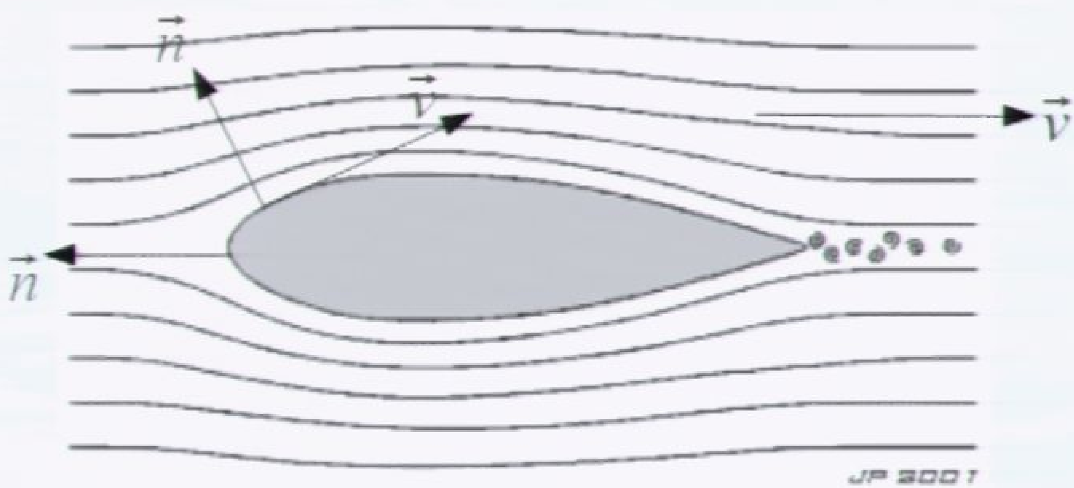

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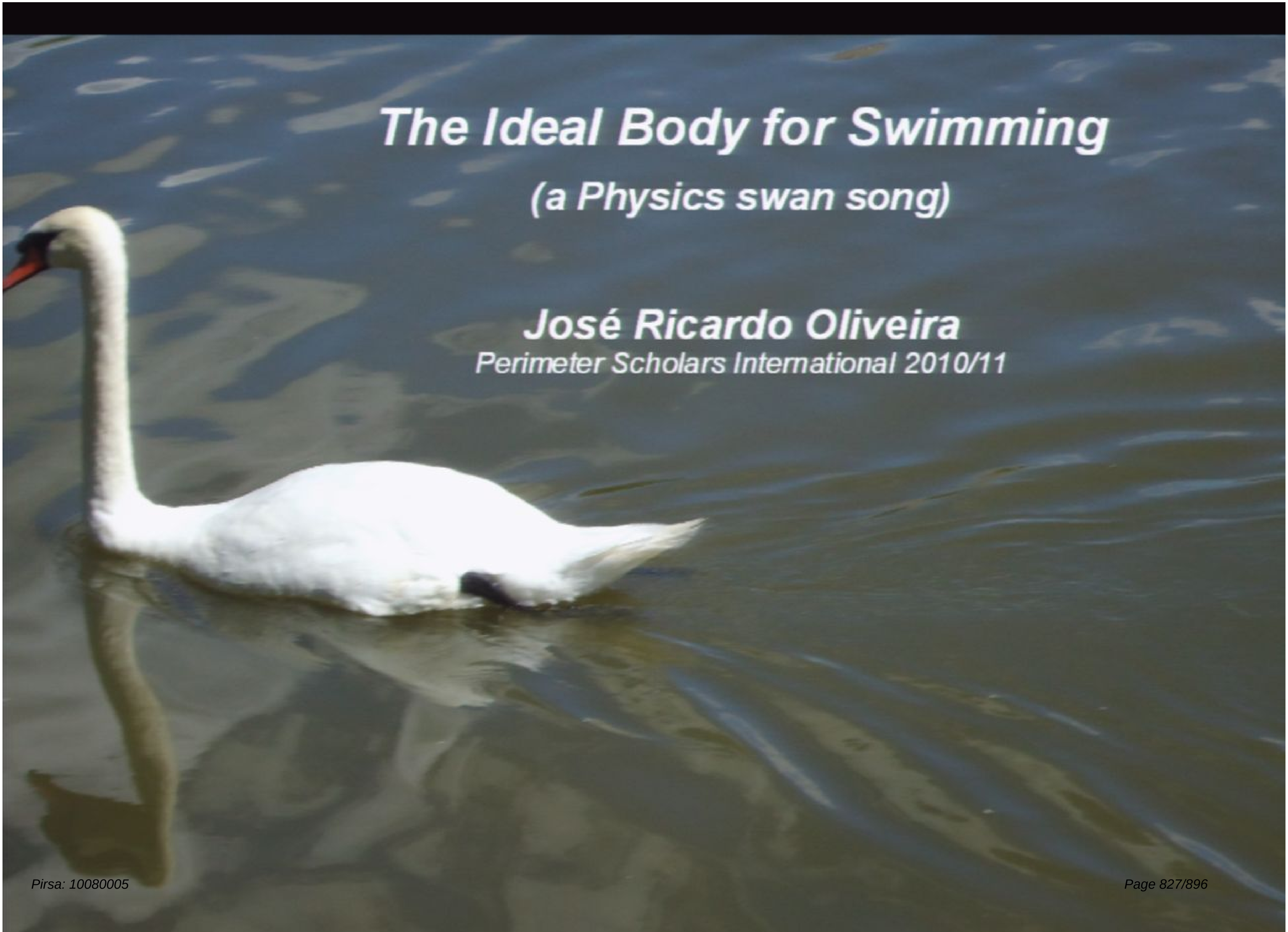
The Ideal Body for Swimming
(a Physics swan song)
José Ricardo Oliveira
Perimeter Scholars International 2010/11

- Streamlined body shapes are seen in most waterbound and flying animals; do they serve a purpose in swimming?

Image: flyfishingnature.com

Image: 123rf.com

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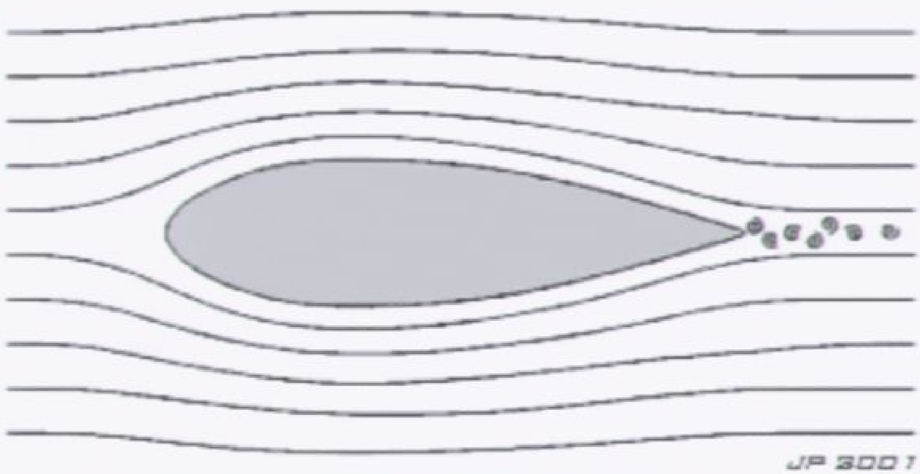

Image: Coilgun Systems website

- Clearly, if there is a point to the animals' body shapes, it is to reduce drag (as it slows you down, and requires a bigger effort to swim)

A WATER WAVE

A WATER WAVE

A WATER WAVE

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A WATER WAVE

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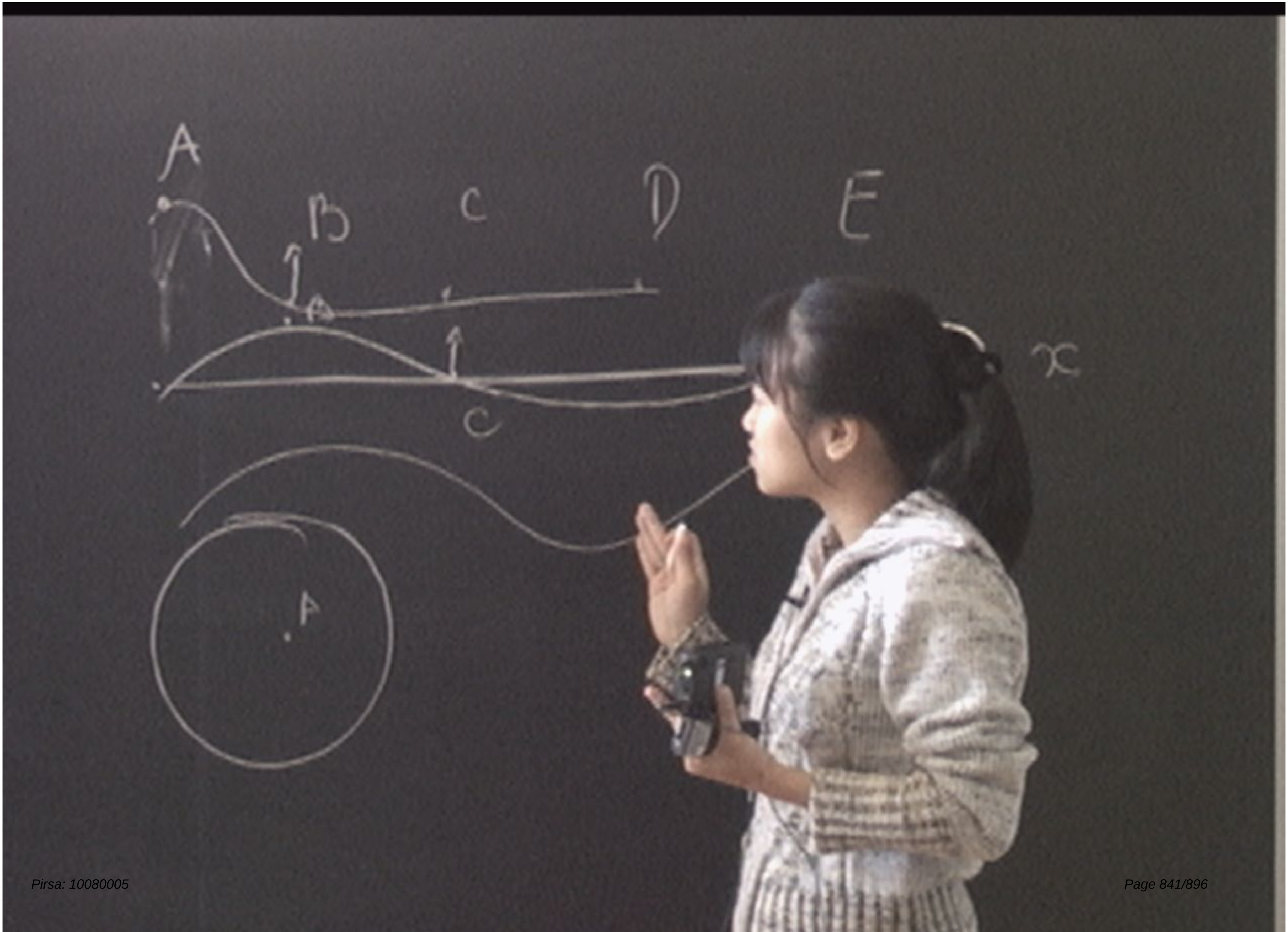
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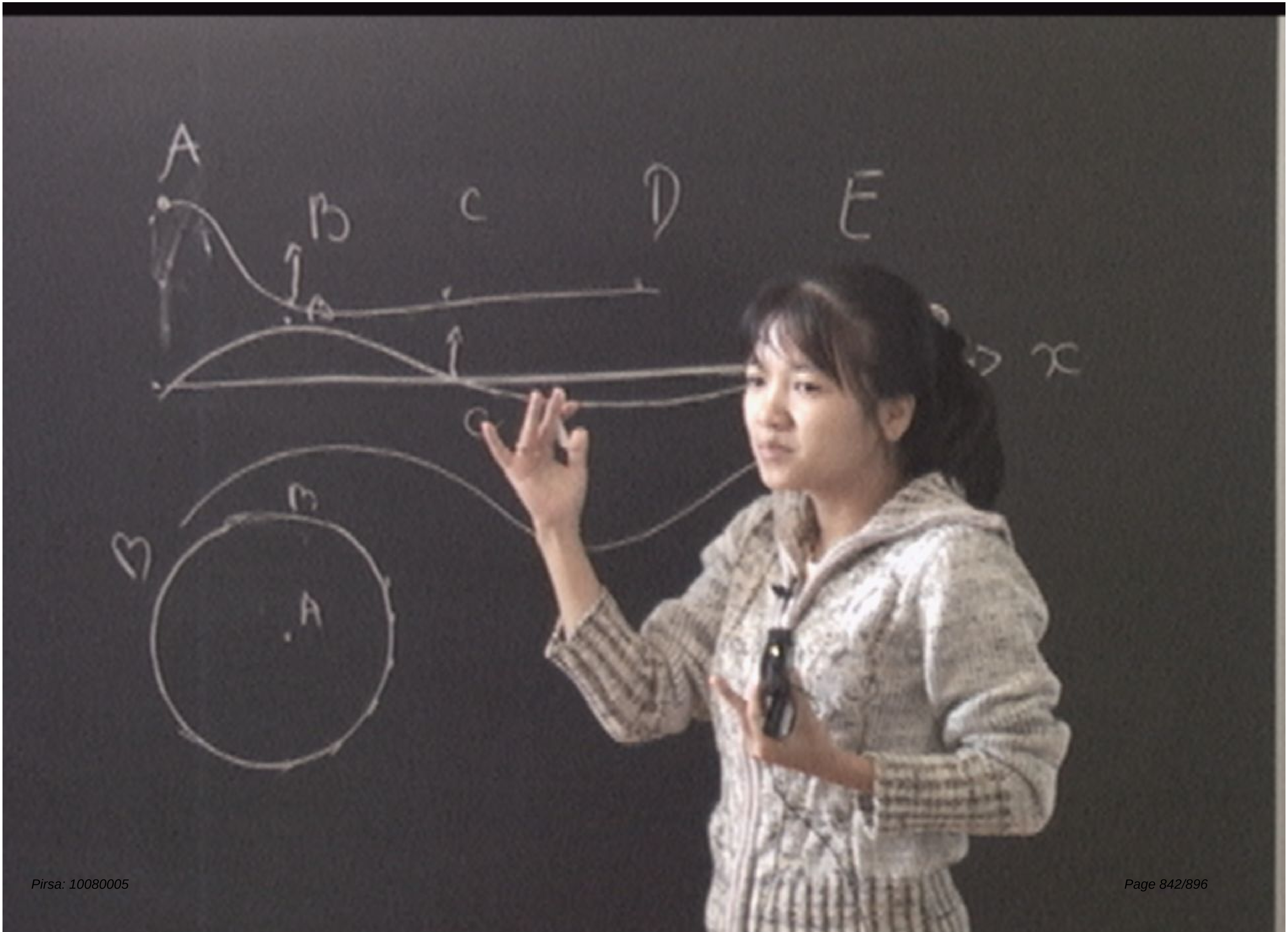
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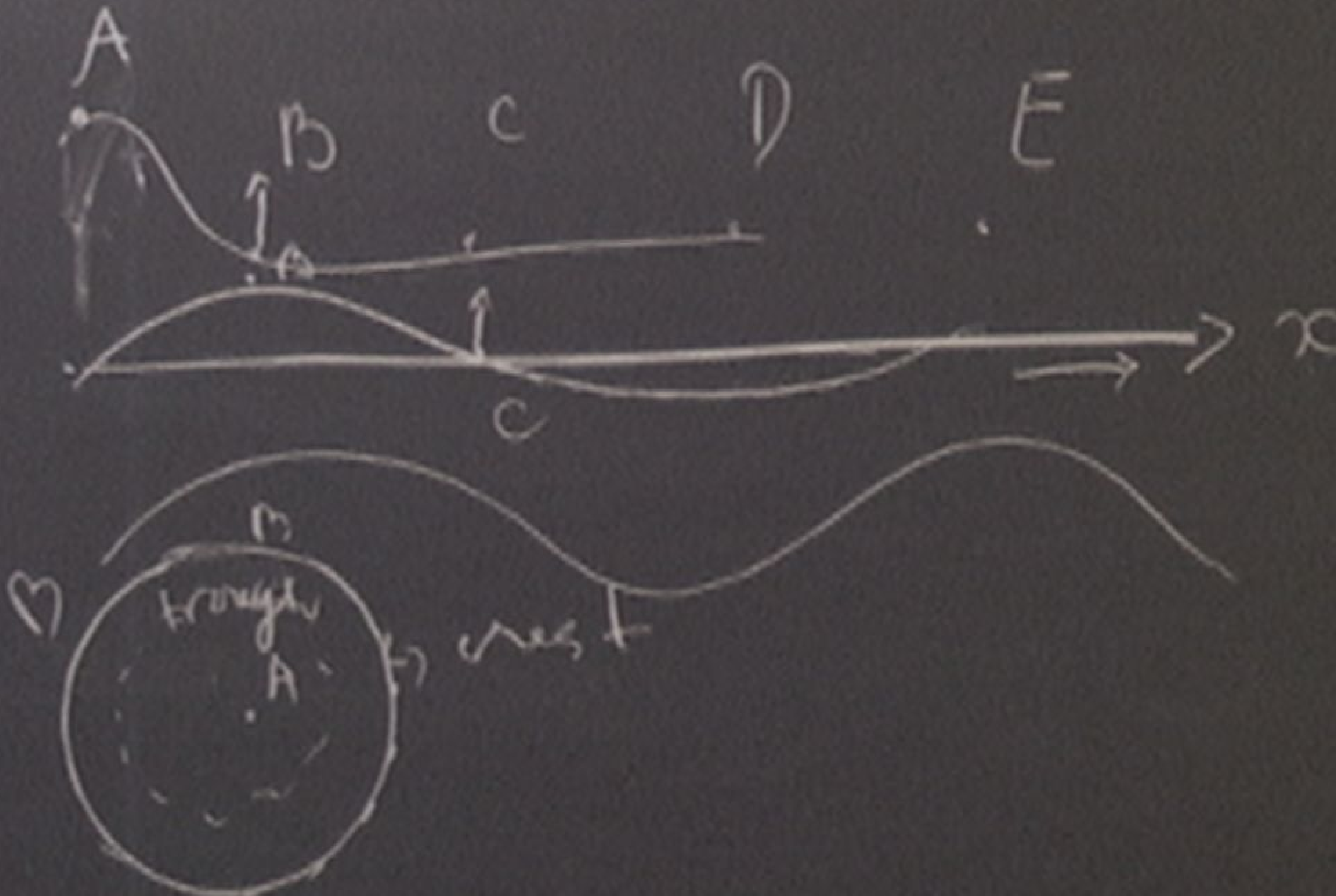
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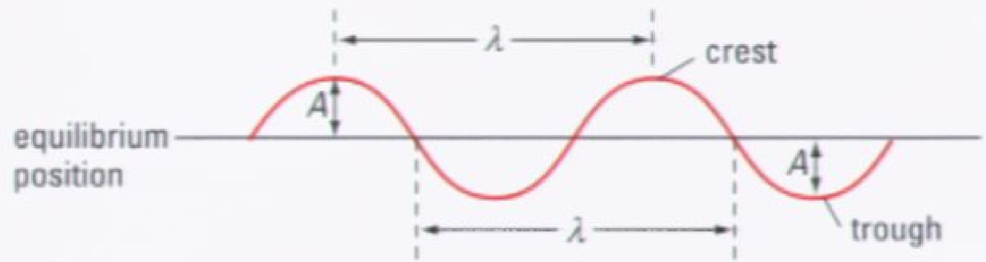
Propagation of vibration



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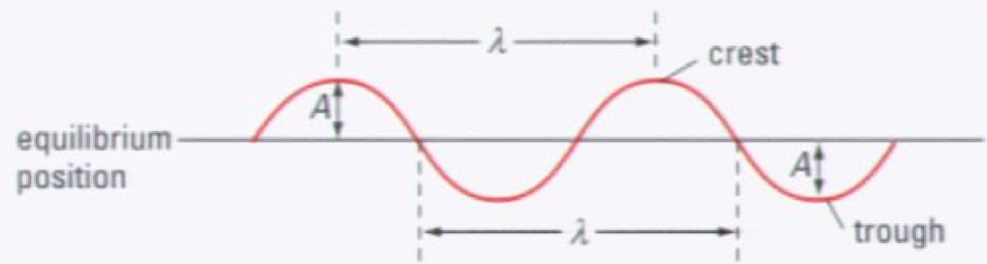

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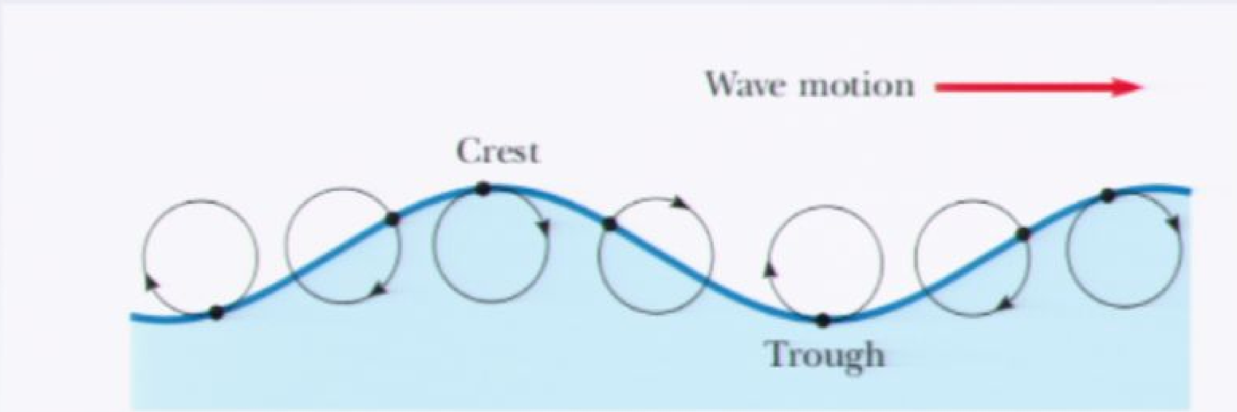
Contents

- Propagation of vibrations
- Types of wave

Is a water wave transverse or longitudinal?

Types of waves



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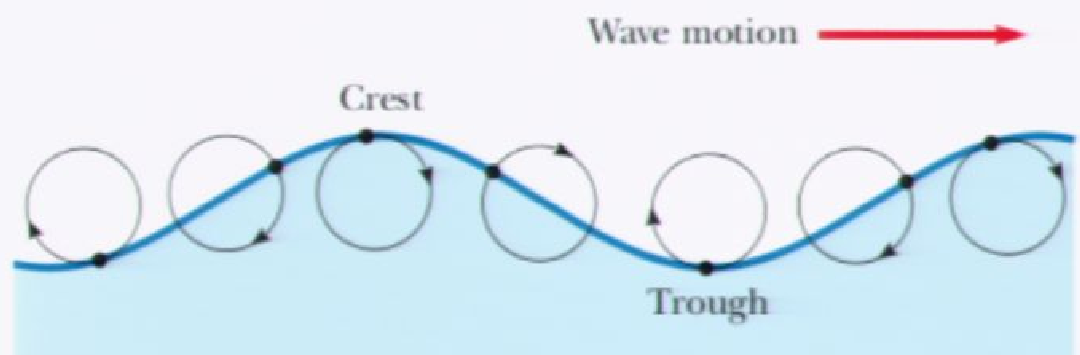
Types of waves



How Candles Burn

Trevor J. Rempel
August 20, 2010

How Candles Burn

Trevor J. Rempel

August 20, 2010

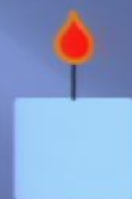
Outline

- Where Does the Wax Go?
- Capillary Action
  - Cohesion and Adhesion
  - Height of Liquid in a Tube
- Rest of the Story
- Conclusion

Where Does the Wax Go?

Where Does the Wax Go?

- Lighting the wick melts wax



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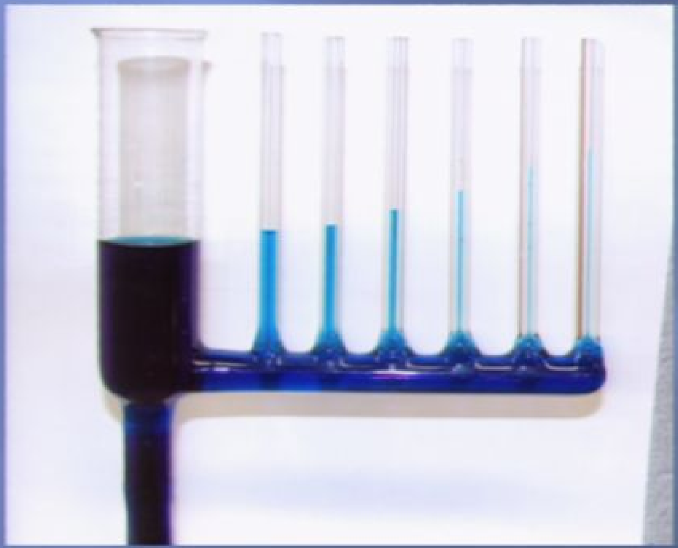
Where Does the Wax Go?

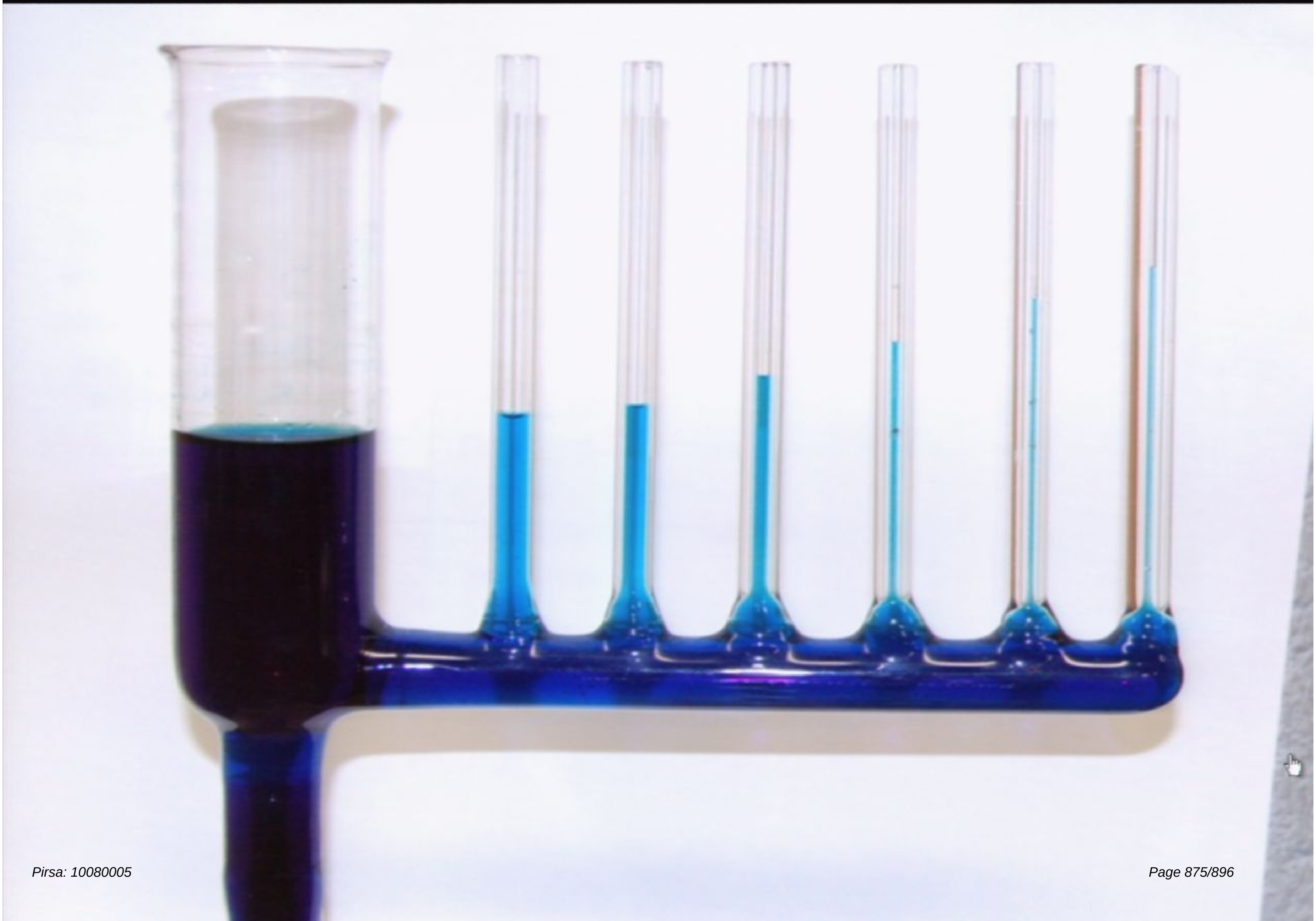
- Lighting the wick melts wax

- Candle burns until wax is gone
- But where does the wax go?

Capillary Action

- Tendency of liquids to rise against gravity





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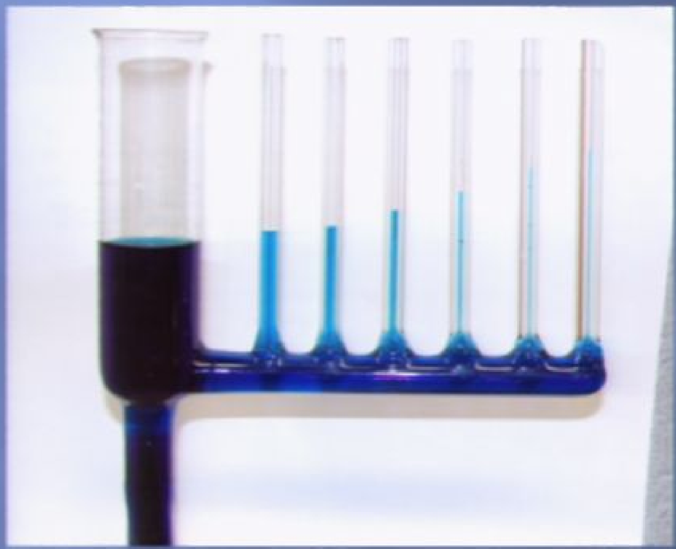

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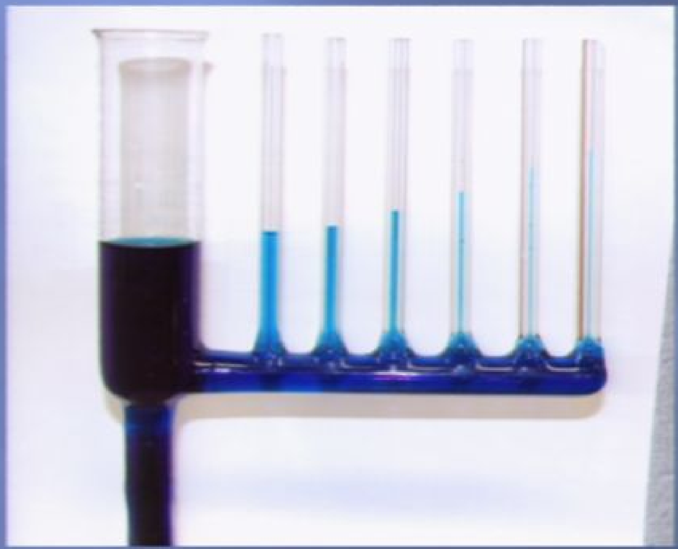

- Common phenomenon
  - Paper Towels
  - Sponges

Cohesive Force

- Intermolecular forces between like molecules

Cohesive Force

- Intermolecular forces between like molecules
- Cause of Surface Tension

Cohesive Force

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- Cause of Surface Tension

Adhesive Force

- Intermolecular forces between unlike molecules

Adhesive Force

- Intermolecular forces between unlike molecules
- Why you need to dry your dishes

Adhesive Force

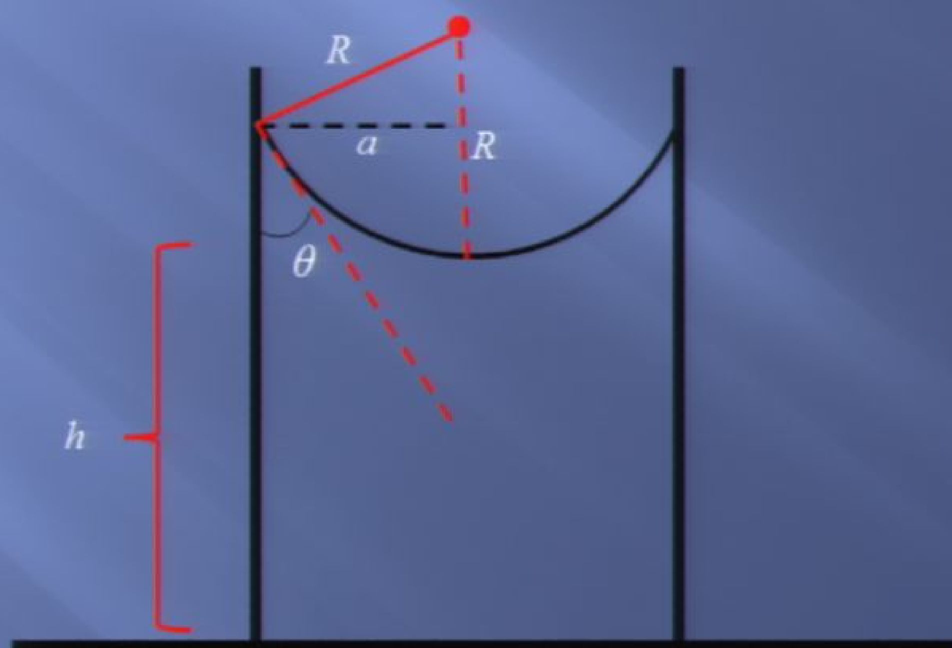
- Intermolecular forces between unlike molecules
- Why you need to dry your dishes

Liquid in a Tube

- Consider a small tube immersed in liquid

- Interplay between cohesive and adhesive forces causes liquid to rise and form a meniscus.

Liquid in a Tube



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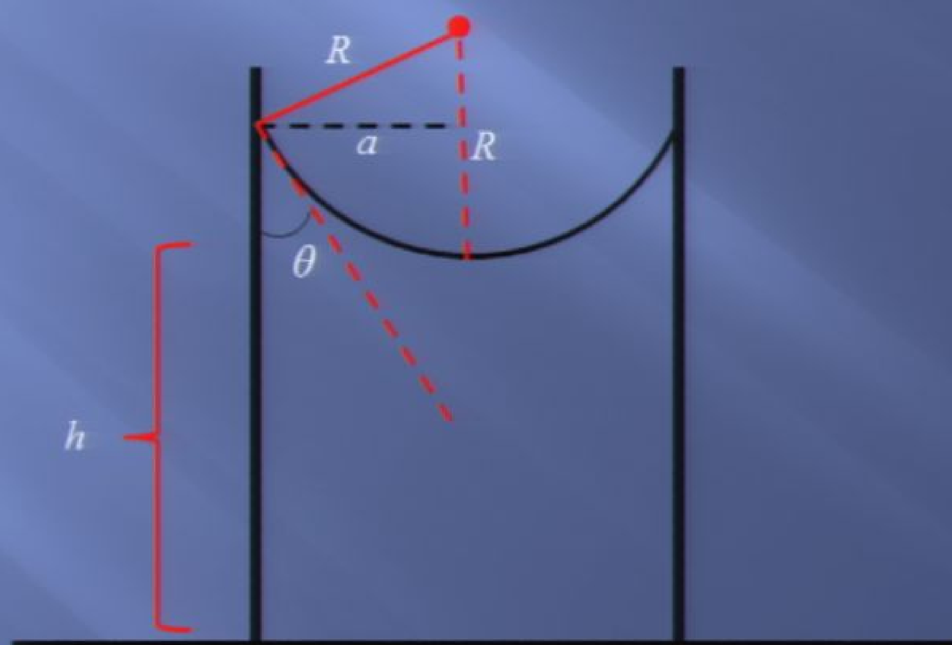
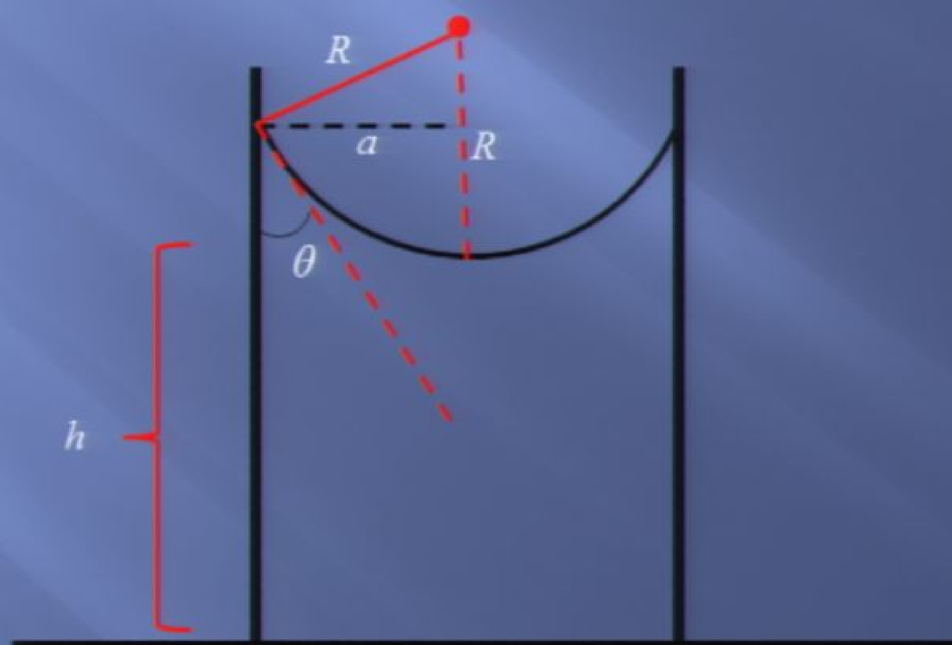


Liquid in a Tube

$$\Delta\text{[illegible]} = \frac{2\,\text{[illegible]}}{\text{[illegible]}} \qquad \Delta\text{[illegible]} = \text{[illegible]}\,h$$



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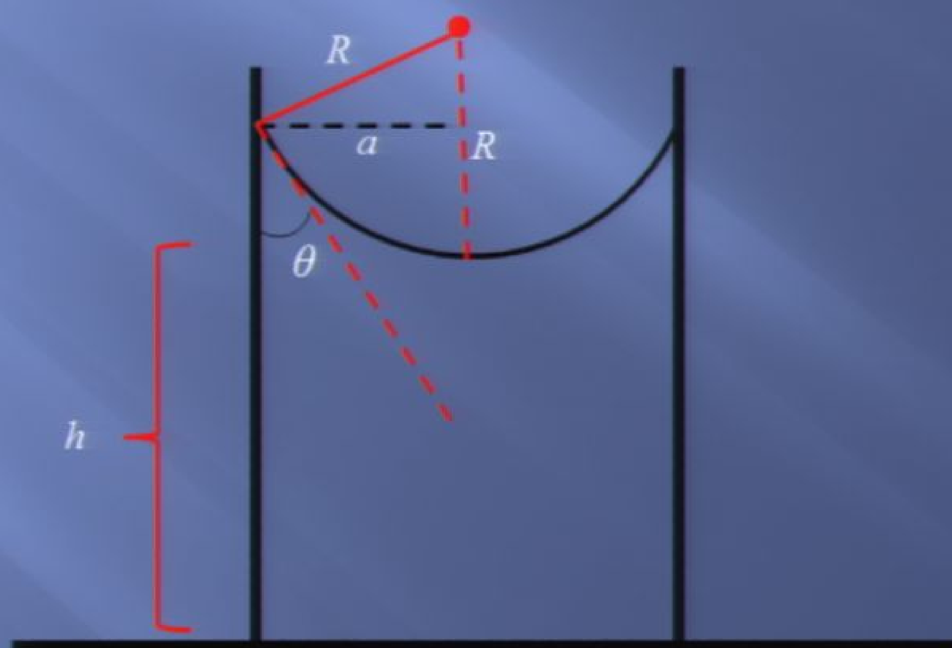

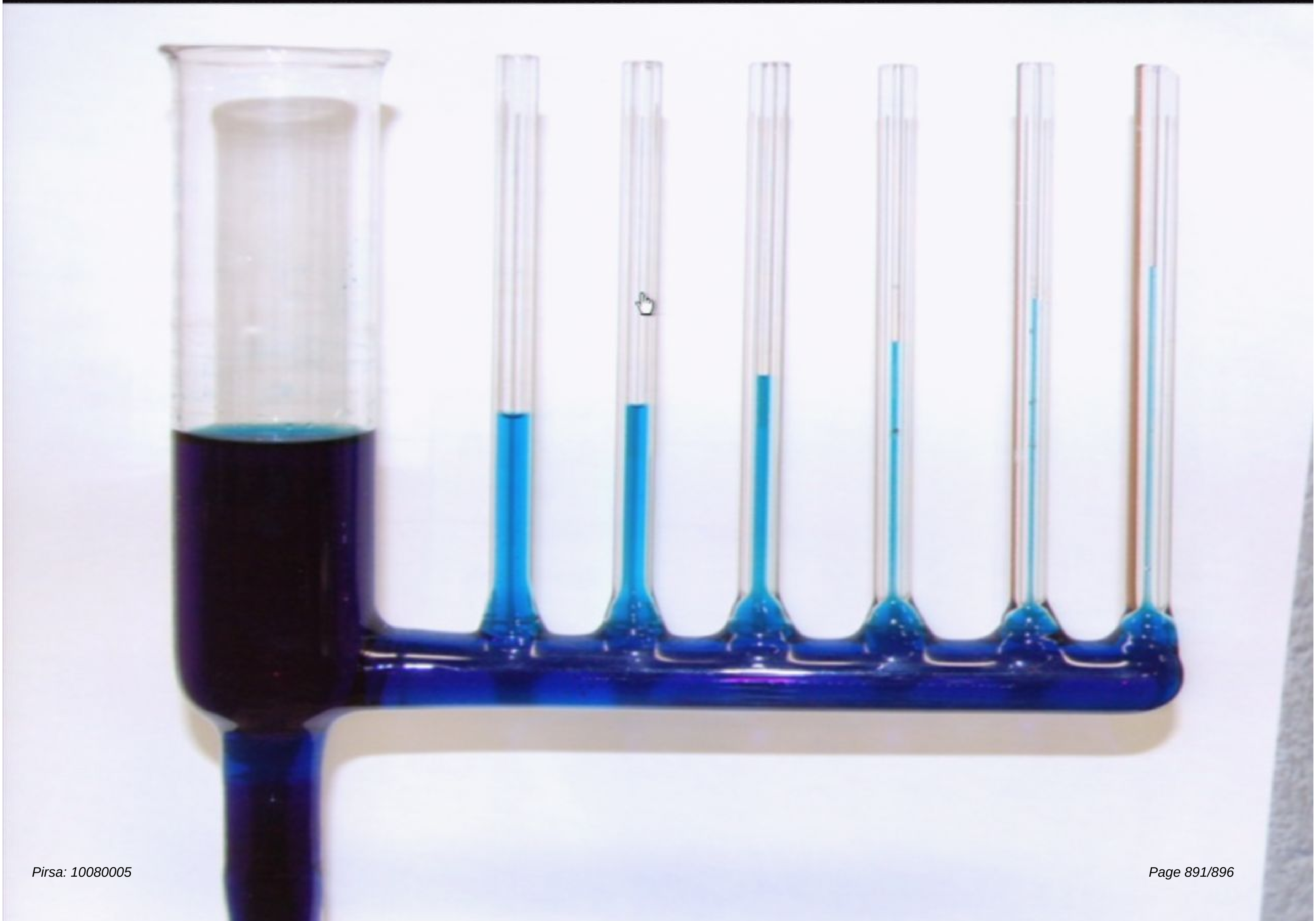

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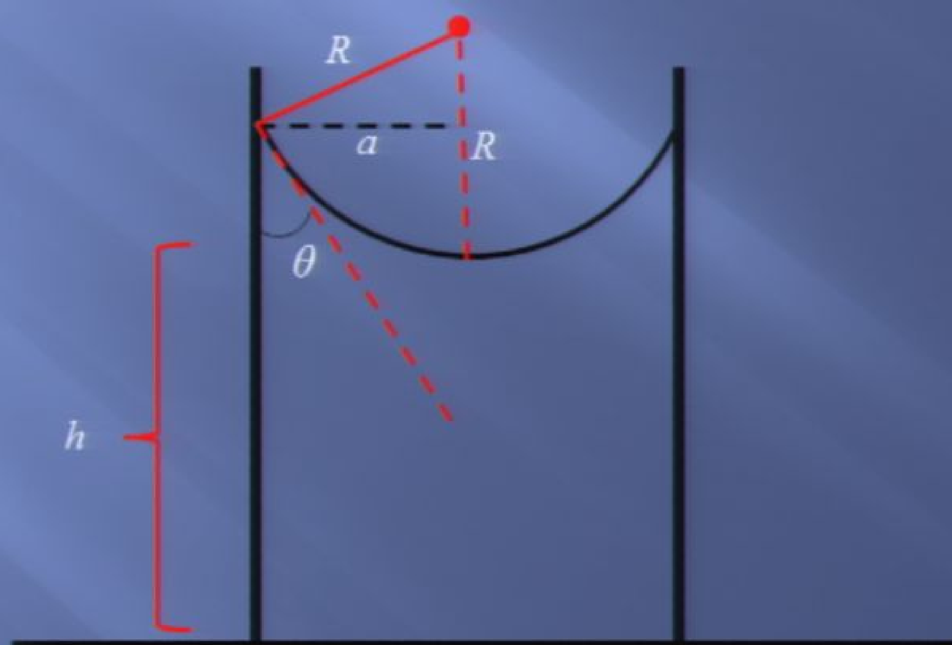
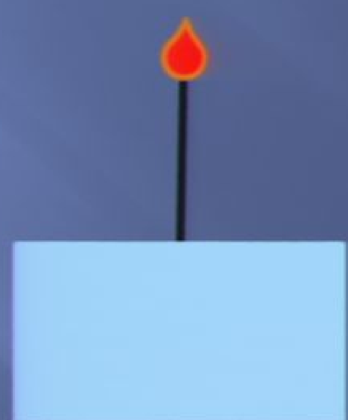


Rest of the Story

- Once wax is melted, capillary action draws wax up the wick



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Rest of the Story

- Once wax is melted, capillary action draws wax up the wick
- Heat from flame then evaporates the wax
- Process continues until wax runs out

Conclusion

- Candle relies on capillary action
- After initially melting wax, adhesive forces between wax and wick draw wax up wick
- Heat from flame then evaporates the wax