



# Expériences : énergie de l'oscillateur harmonique



- Hurler dans un verre
- Pont de Tacoma
- Transfert d'énergie entre modes : Wilberforce
- Synchronization

Mécanique | 2013 6

Hello. Welcome to the EPFL General Physics class. In this lesson, we looked at the energy of a harmonic oscillator. Here, I'd like to go a bit further by looking at some experiments. First, we're going to have fun screaming into a glass and you'll see that, well I hope you'll see it, you'll hear it, that you have to scream very, very loudly to manage to break a glass, screaming into the glass. Then, I will discuss for a while the Tacoma bridge, the famous bridge that broke, due to a wind oscillation, which I will describe later. Then, we will look at the following phenomenon. We will show that it is possible that there are several oscillatory modes, to a system and that the energy passes from one oscillatory mode to the other. And finally, we will finish with a funny experiment, which shows the synchronization of clocks when these clocks are slightly coupled.

Notes

Summary



0m 03s

# Hurler dans un verre



- Un son excite la résonance d'un verre ballon.
- La déformation à haute fréquence est considérable !

Mécanique | 2013 7

I'll start with the balloon glass experiment. You see in this picture, a device that is basically used to power a speaker, which is on the left side of a balloon glass. There is a tray. You assume that the glass is going to break, so the tray is there, underneath the glass, to collect the debris. And the technician will adjust the frequency of the sound, to excite the resonance of the balloon glass. When he increases, there is a subtlety. When he increases the amplitude of the sound, the amplitude of oscillation of the balloon glass increases, which makes the balloon glass breathe more air, which makes the damping increase, and so the natural frequency changes slightly. That's why you'll see him finely adjusting the frequency of the speaker. Let's observe and listen. Unfortunately, it's hard to account, on the mooc, for the din this experiment makes in the audience.

Notes

Summary



1m 12s



The stroboscope allows to visualize the oscillations of the edge of the balloon glass. You will see. Here are the finished adjustments. Now you can see the edge of the balloon glass oscillating much more slowly than the sound, that's the stroboscope which allows you to see that. And there it is.

[illegible]

## Summary





Usually, students are particularly amused when the glass breaks, so I offer you a slow motion video of the balloon breaking. If you don't mind, I'd still like to make a comment. You observe here a singular property of materials, it is the possibility to have a deformation of a considerable amplitude at high frequency. If we wanted to do the same deformation at almost zero frequency, so by hand or with pliers, we would never have such a large deflection. I continue. And there you go.

Notes

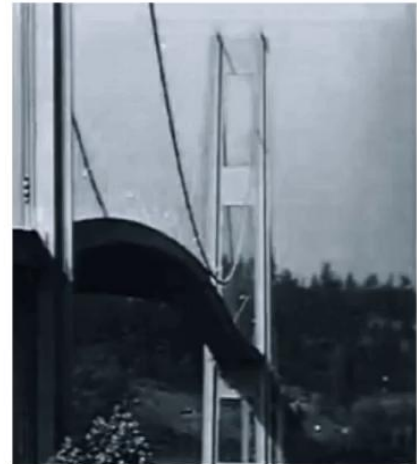
Summary

3m 11s





# Pont de Tacoma



- Oscillation entretenue par l'effet combiné (complexe) du vent et de la déformation du pont.
- Amplitude sans rupture : remarquable !

Mécanique | 2013 9

Often when we talk about resonance, people like to show the film of the Tacoma bridge, a bridge that had just been built and was subjected to very high winds and, as you can see in this picture, the bridge deck started to sway. It's a very spectacular film that you can easily find on the internet. I would still like to point out here that, when we defined resonance, we took a harmonic oscillator, we subjected it to a force that oscillates in time, like a  $\sin \omega t$  or  $\cos \omega t$ , so it's a force with a harmonic time dependence on frequency, and we're in the vicinity of the frequency of the resonance eigenmode. This is not what happens here. Far from the bridge one can imagine that the wind is uniform and constant. And it is a particular interaction between the wind, the turbulences, and the oscillatory modes of the bridge which generate, basically, what we must call a self-resonance.

Notes

Summary



4m 10s



- Mouvement harmonique de translation
- Mouvement harmonique de rotation ...

Mécanique | 2013 10

In the following experiment, called the Wilberforce pendulum, I would like to show how the energy can change from one oscillatory mode to another. What you see on the picture, is a gallows holding a very long spring with a mass at the end. And you look, the camera is underneath the system. I'm not saying anything more, I'll let you observe.

Notes

Summary



5m 18s



We're gonna shoot. So we make a translation movement and a rotation is engaged, so much so that, you see there, the translation energy is zero, and all the energy is in the rotation. And after the oscillation, so, the translation starts again and the rotation stops. And it starts again.

Notes

Summary

5m 45s







- L'énergie passe d'un mode d'oscillation en translation à un mode en rotation

Mécanique | 2013 11

I invite you now to look at the same system from the side. First, we will engage a translation mode, and we will see the system start rotating, and then we will do the opposite.

Notes

Summary



6m 27s



Translation. Rotation. And we'll go back to translation. Now I'll show you the reverse. We'll start with the rotation. And here's the translation starting. Here it is.

[illegible]

## Summary



# Synchronisation des pendules couplés



- Les métronomes ont des fréquences propres différentes.
- Sur la planche, ils battent la mesure ensemble.

Mécanique | 2013 13

To finish this module, I'd like to show you an amusing experiment, on the synchronisation of clocks. If we wanted to account for this phenomenon, we would have to do much more advanced mechanics than what we are trying to do in this course. We would have to examine non-linear mechanical systems. So, here you have six metronomes, all identical, set, as well as possible, at the same frequency. So when you start them, they beat together. But very quickly, there are differences. The film starts after a few minutes, and the clocks, the metronomes, are no longer in unison. Then, we'll put the board on a support which allows a light rolling, and you'll see that the pendulums, well the metronomes, synchronize.

Notes

Summary

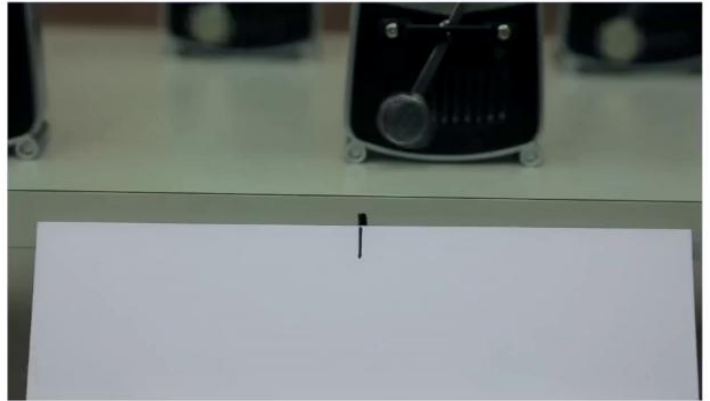


7m 34s

- Notes



# Synchronisation des pendules couplés



- Le couplage entre les métronomes provoque leur synchronisation !

Mécanique | 2013 14

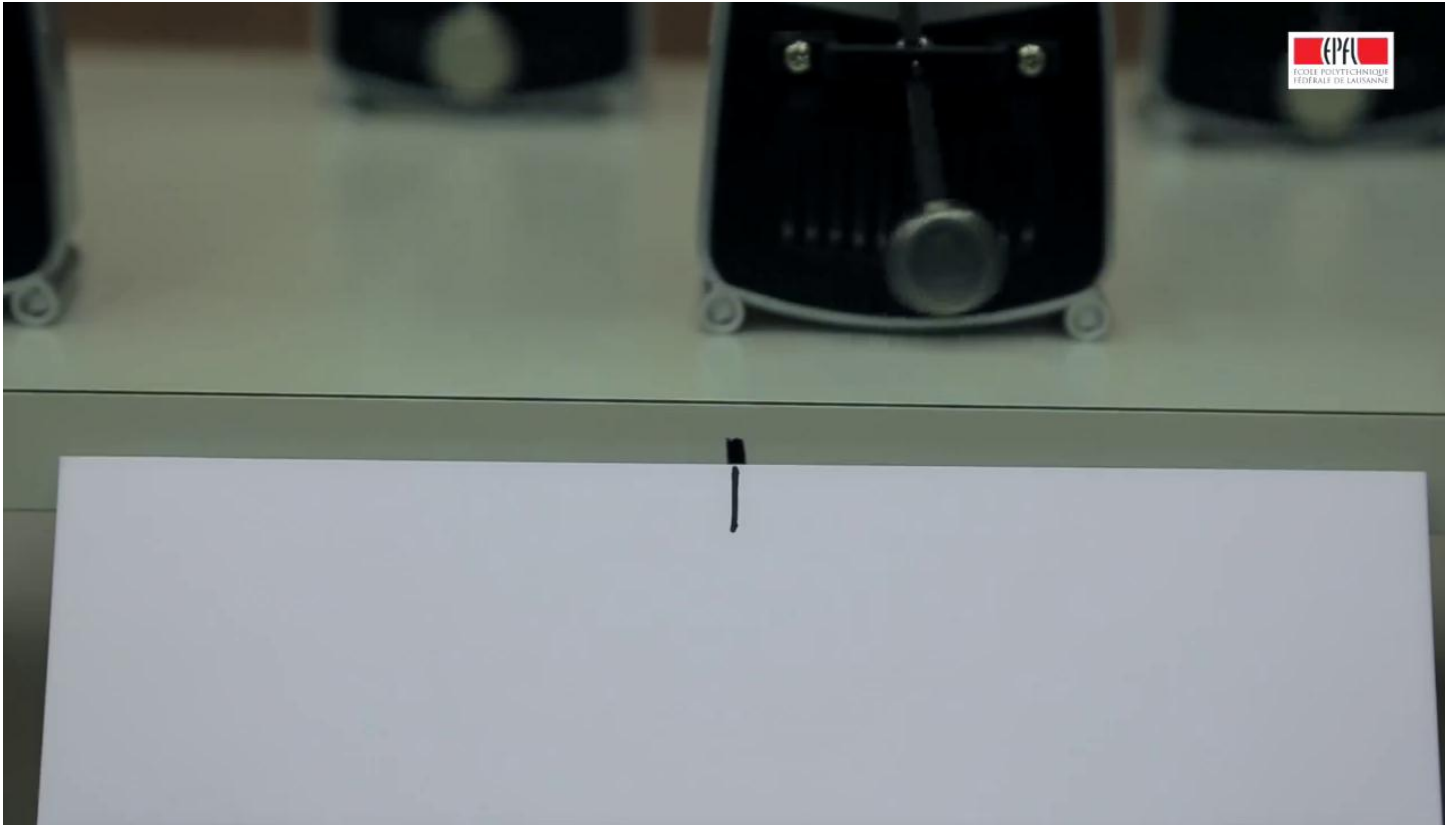
That's it. To illustrate the fact that there is a coupling between the metronomes, when we put the board on the two cylinders, the technician has made a small location of the board's position. And you will see that the board moves a little bit.

Notes

Summary



9m 51s



Like this.

[illegible]

## Summary

