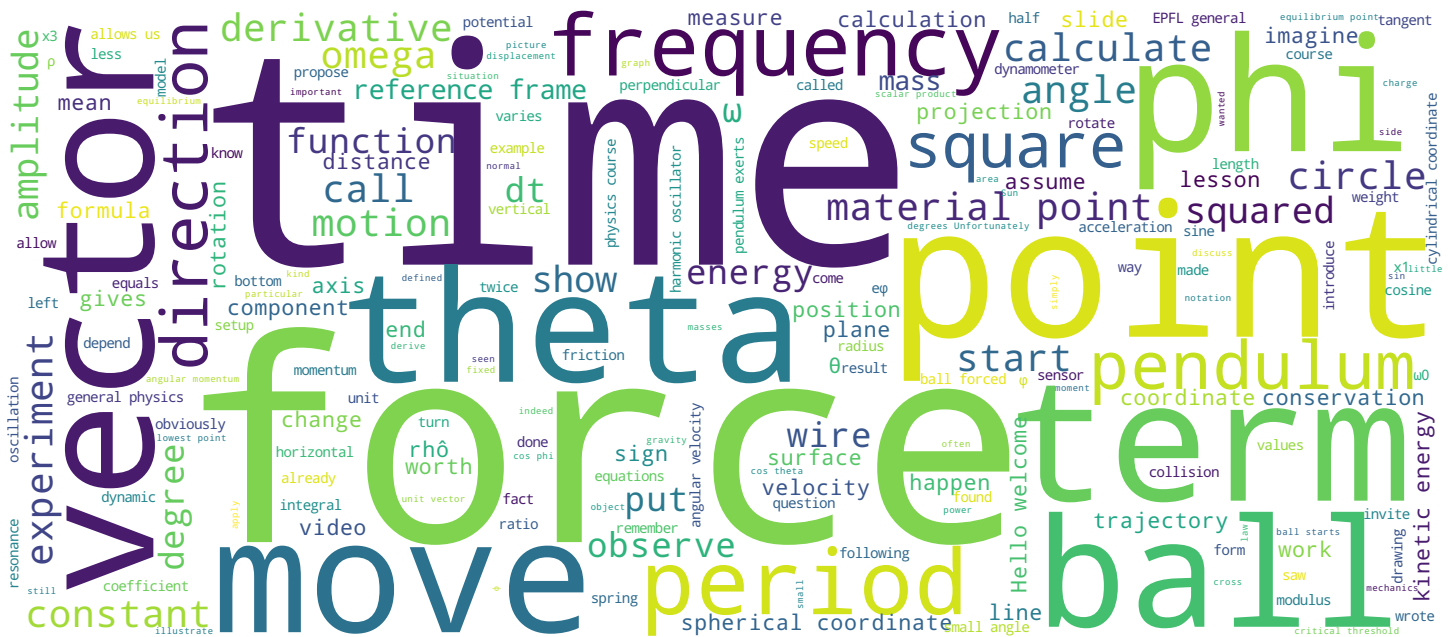


Expériences : contraintes géométriques

Mécanique, cours 9.exp

Jean-Philippe Ansermet



Video





- Dynamomètre sur un pendule
- Période en fonction de l'amplitude
- Bille sur une surface
- Bille sur glissière en rotation

Mécanique | 2013 6

Hello. Welcome to the EPFL general physics course. In this lesson, we saw that, a lot of physical systems could be represented by a material point forced to move on a line or a surface. Here, we will discuss this kind of problem with experiments and first, we will show the force that the wire of a pendulum exerts on the weight that is hanging on the end of a pendulum. Then, we will measure the period of the pendulum as a function of the amplitude. We'll look at a ball forced to move on a surface. Instead of moving on a line, the ball moves on a surface, and finally I will look at the dynamics of a ball constrained to move on a slide which turns on itself.

Notes

Summary



0m 04s

Dynamomètre sur pendule



- Le fil du pendule est maintenu à son extrémité par des poulies.
- Un dynamomètre mesure la force que le fil exerce sur le poids du pendule.

Mécanique | 2013 7

I start with the force that the wire of a pendulum exerts on the weight that we hang on the end of the pendulum. On this setup, instead of having a fixed point, the wire passes between two pulleys and the wire is then hooked to a dynamometer, which allows us to measure the force the wire exerts at all times. Let's look at what happens on the dynamometer.

Notes

Summary



0m 58s



We see that the force oscillates with a frequency of oscillation which is twice the period of the pendulum, which is normal given the symmetry of the problem, we should expect that, we have a left-right symmetry and so the force on the left should be equal to the force on the right, so we have twice the frequency.

Notes

Summary



1m 31s

Période en fonction de l'amplitude



- La fréquence d'oscillation est plus petite aux grandes amplitudes qu'aux petites

Mécanique | 2013 8

Now let's look at the question of the frequency of the pendulum as a function of the amplitude. Here, it is not the period that the little device will measure, so we have a pendulum mounted on a rigid frame, and there is a sensor at the base. The sensor then measures the time between two swings and translates it into frequency. Let's see what we observe starting with an amplitude of 90 degrees. Unfortunately on this setup we can't go higher. Well, it's not quite 90 degrees. And then, there is an experiment that is conducted at 45 degrees and at very small angles.

Notes

Summary



1m 53s



We look at the experiment. Here is the frequency sensor. This is about 45 degrees. And the very small angles. Here is the sensor.

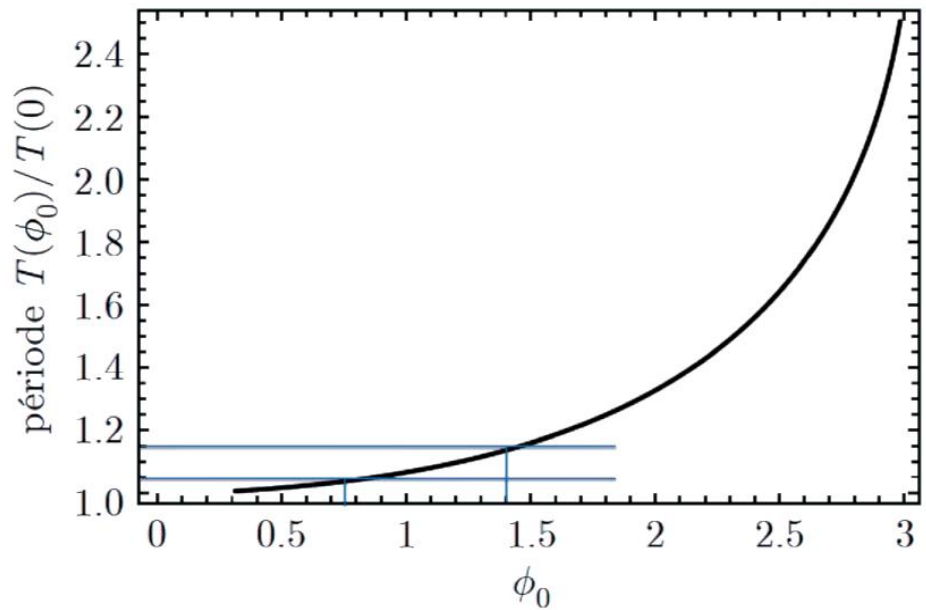
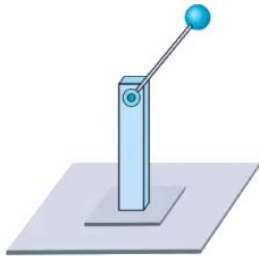
Notes

Summary



2m 35s

Période en fonction de l'amplitude



Mécanique | 2013 12

I spotted the three frequencies and I wanted to compare them to the theory I had mentioned. I had not done all the calculations, you remember, about a pendulum such as this one, I had given a graph of the period normalized to the period of the amplitudes infinitely small as a function of the angle at the maximum amplitude. So here, we have a point at a little less than 90 degrees, this is radians, so 90 degrees is here. And we have a value at about 45 degrees. I plotted these values like this with the values, you see that this is the period, so from the frequency I deduced the period, I normalized by the period to the small amplitudes. I translated that, the ratio in frequency, and here are the two ratios. We can see that the most spectacular part takes place at more than 90 degrees. Unfortunately the editing does not allow to do that. I invite you to design your own montage to try to do it by yourself.

Notes

Summary



3m 16s

Bille sur une surface



- On note l'importance de la rotation rapide autour de l'axe vertical dans le mouvement de descente dans le puits défini par la surface.

Mécanique | 2013 13

Here is a ball forced to move on a surface. You could imagine to do the calculation and get the trajectory. Look, something funny happens when the ball reaches the bottom of the funnel.

Notes

Summary



4m 26s



See already that the trajectory is quite complex.

Notes

Summary



Bille sur glissière en rotation



- La glissière hémisphérique tourne autour d'un axe vertical à vitesse angulaire constante.

Mécanique | 2013 14

Now I'll go to the problem of the balls forced to move on a circle. The circle is itself rotating. I had shown this setup to illustrate the use of spherical coordinates. Here I want to show the dynamics of a ball in this slide. So we put two balls; The red one is at the bottom at the lowest point, the green one is slightly shifted, and we are going to look at what happens when the system starts to rotate. We will observe that there is a critical speed, beyond which the equilibrium point is there, we will observe that the ball oscillates around this equilibrium point.

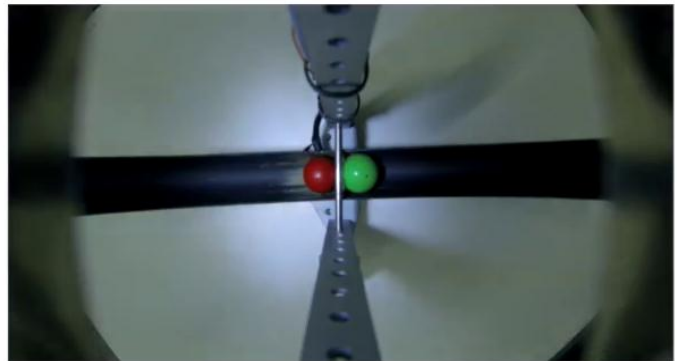
Notes

Summary



5m 04s

Bille sur glissière en rotation



- Au-delà d'un seuil de vitesse angulaire, la bille oscille autour d'un équilibre hors de l'axe de rotation.

Mécanique | 2013 15

So let's go to the video. This video is made with a camera mounted on the frame that rotates with the slide, which allows us to observe the balls well.

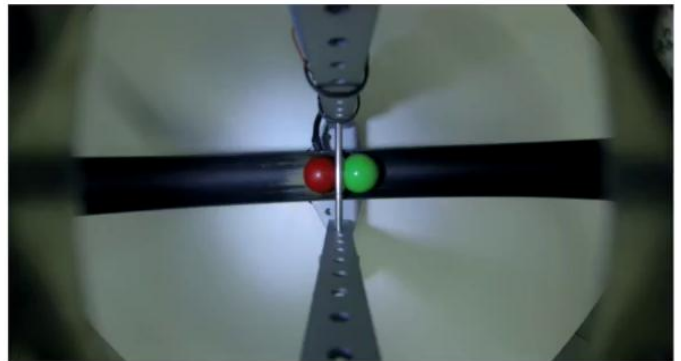
Notes

Summary



5m 44s

Bille sur glissière en rotation



- Au-delà d'un seuil de vitesse angulaire, la bille oscille autour d'un équilibre hors de l'axe de rotation.

Mécanique | 2013 15

That's all for today.

Notes

Summary



6m 29s