The device is theoretical

1/ Goal:

Give an example where the sum of energy is not conserved to break the law of the conservation of the energy.

2/ Method:

I study the sum of the energy during a deformation of a device, the device doesn’t return to the start position. Even during a deformation, the sum of energy must be kept constant. I give the calculations for a small and for a big angle.

3/ Simplifications:

- no mass, all components have a mass at 0
- no friction
- the force of the springs is constant, doesn’t depend of the length of the spring
- the springs have no volume
- no gravity

In theory, I’m not limited to the size of the atoms and I can take the walls thin like I want. With limits I can cancel some problems.

Sure, the device works with mass, gravity, and a realistic force for the springs but the calculations are more complex. The volume of the spring is a problem but it is possible to think with only a layer of spheres for the device and the springs outside.

4/ The device is unstable:

The device needs another external device to control it. All must be controlled: walls, spheres, springs, etc. That external device controls but measures in the same time all the energies out/in. That external device is not drew. In the description I didn’t speak about that external device, I suppose all is needed to do to deform the device is done by that external device.

5/ What the device needs :

- a gradient of pressure
- the source of the gradient must be on the device
- move out/in some parts and a rotation

I need a gradient of pressure, for that, I use small spheres and springs. Small spheres are like molecules of water and the springs attract like gravity can do. I can’t use the gravity and a fluid like water because the source of attraction must move in the device and it is not possible on Earth, I done calculations for a device with water under gravity and it doesn’t work. Molecules of water have a mass but I don’t need mass so like that can simplify the calculations I take the mass at 0 for the spheres. One end of the springs is fixed on the green line (the bottom wall) the other end is fixed in the center of each sphere. There are a lot of spheres like there is a lot of molecules of water in the glass of water. I gave the force of the springs in N/m^3 like that if I change the size of the spheres that doesn't change the results.

6/ Spheres packing:

I didn't take in account the spheres packing. In standard, the coefficient is 0.74 if there is only one size for the spheres. If I take only one size for the spheres, all the results I gave need to be multiplied by 0.74. But it is also possible in theory to filled the container with different diameters of the spheres. Like the force of the springs is in Newtons by a volume, the results are the same than mine.

7/ Springs:

Each spring has a potential energy, F*Lg with F the force of the spring, for example, F=1e-15N for a volume of a sphere of $1e\text{-}15m^3$, Lg is the length of the spring. The force of the spring is supposed constant. If I change the length of the spring I change the potential energy of the spring. If the length of the spring increases then the potential energy stored I the spring is increased. If the length is decreased then the potential energy is decreased. The springs pull.
The orientation of the springs is the same at a time but change when the device is deformed. I symbolized the orientation of the springs with the red line in the drawings. Like that, I can use the law of pressure of a fluid in a gradient of pressure (like water under gravity for example), it is easy, I don't need to calculate all the forces for each sphere.

8/ White bars:

To be forced to move out and move in something, I use bars (white color). You could imagine the bars like polystyrene, but I take the mass at 0. It is possible to imagine the bars empty too. The length of the bars must be decreased because the bars turn around their axes when the device is deformed.
The orientation of the bars is the same than the lateral walls.

Why take the thickness of the bars very small ? Because, the green line moves like the lateral walls and if I want to have the same orientation of the springs than the lateral walls I need to have the thickness of the bar very small. The right part of the bar don't give a big problem because the spheres are adding in that area. The left part of the bar moves more than the green line and that length depend directly of the radius of the purple axis. I can change the shape of the purple axis from a disk to a half disk.

9/ Buoyancy force:

Like an object in water under gravity has a buoyancy force (Archimedes), it is the same here. Especially for the spheres, each sphere has 2 forces on it. One force from the spring, the other from the others spheres all around (buoyancy force). The sum of forces on each sphere is 0 N. So when the springs change their length, it is impossible to recover that energy (or give an energy for that).

10/ Time:

Like there is no mass, the device is more unstable than with mass. All movements could be done with a duration near 0. So, the external device is there to cadence the movements. But at each time:

- the orientation of the springs is the same
- the volume of the container is constant at $1m^3$
- the volume is fulled at $1m^3$ (filled with bars and spheres)

11/ The device is composed of:

- a container, the volume is $1m^3$, the walls are perfect, the depth (perpendicularly to the screen) is 1 m
- spheres: very small like molecules of water, but without mass nor friction, the spheres transmit pressure perfectly
- springs: one spring for each sphere, no volume, no mass, the force is constant (doesn't depend of the length of the spring)
- bars: empty, no mass, walls are perfect
- axes of rotation: no friction

12/ Geometry:

I used an arbitrary geometry: a parallelogram (side view) but it is possible to change it. I deform the parallelogram to a square (side view), again it is arbitrary. It is possible to use another shapes. In 3 dimensions, the device is a parallelepiped and it is deformed to a cube.

13/ Size of the elements:

No matter the size of the spheres or bars:

The volume of the container is 1 m^3
The volume of the white bars inside the container is near 1 m^3 at start and 0.707 m^3 at final
The volume of the spheres inside the container is near 0 m^3 at start and 0.293 m^3 at final

First case: realistic dimensions

The radius of one sphere could be at 1e-5 m
The thickness of walls could be at 1e-7 m
The thickness of one bar at 1e-3 m

Second case, like the device is theoretical it is possible to have:

The radius of one sphere could be at 1e-100 m
The thickness of walls could be at 1e-80 m
The thickness of one bar at 1e-40 m

Why so few ? Because it is possible to imagine small torques on the bars and some residual areas at top due to the purple axes of rotation and some problems from the orientations of the springs.

<u>14/ Orientation of the springs:</u>

To have the right to use the simplified formulas of a fluid under a gradient of pressure I need to have the same orientation of the springs. There is a problem because when I move in a sphere inside the container and fix the spring on the green line, the green line moves with the orientation of the lateral walls and the white bars rotate like the lateral walls. Each spring attached on the green line is supposed to be fixed, but if I do that, I have a small difference between the springs and the lateral walls, that difference of orientation is near 0 when the thickness is near 0. So, in theory it is correct. I give the calculations of the energy needed to correct the orientation of the springs at the end of the document.
It is possible to think in 2 steps, the first step: I deform the device like I explained, the second step: I correct the orientation of the springs. I think the second case don’t need an energy because the springs attract, so I lost a potential energy (already counted in my calculations) and I win the an energy to correct the position of the springs, but like I said, the distance is very small IF the number of bars is big.

<u>15/ The walls:</u>

I supposed the walls perfect. No friction to modify the shape of the walls. The walls are perfectly waterproof, I mean nothing can pass through the walls. In theory, it is possible to take the thickness of walls at 1e-100 m if it is necessary.

<u>16/ Create/destroy the energy:</u>

The device I used creates the energy, but it is possible to deform the device from end to start like that the energy is destroyed.

<u>17/ Colors used:</u>

- red : orientation of the springs
- blue: small spheres, so small I drew them like water, blue color
- green: line where all the springs are attached
- black: the external walls of the container (only in the first drawing)

<u>18/ Writing conventions:</u>

- I write ‘up’ or ‘down’ it is relatively to the screen because there is no gravity
- the depth is perpendicularly to the screen
- all views are side view (except if I wrote something else)
- units are SI
- angles are relatively from the horizontal

- I gave the integrals in positive values but I indicate if the energy is positive or negative

19/ Drawings conventions:

I needed to take choices. It is impossible to draw all spheres ! And even less the springs ! So I didn’t draw the springs, and I drew only a color for the spheres, like I could do for water. I drew a limited number of bars, I can’t draw 1000 bars.

20/ Pressure:

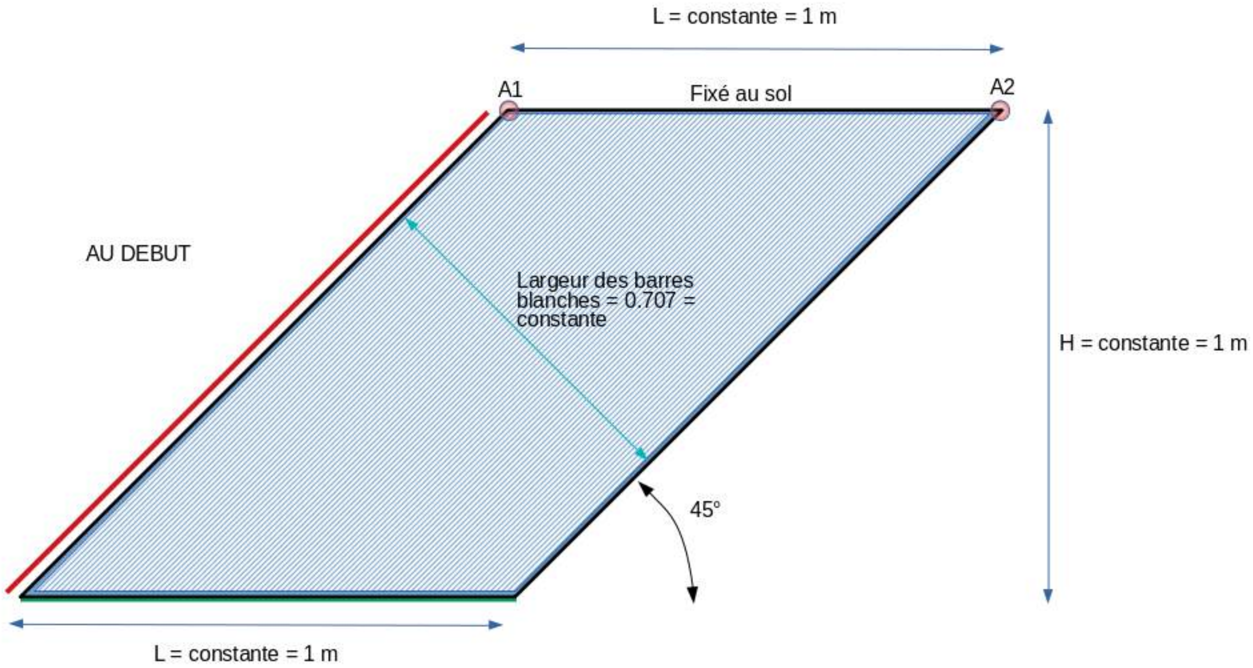
Each sphere acts like a perfect molecule of water, and gives the pressure in all directions. I noted some pressures ‘p=’. Pressures are in Pascal, Pa. The pressure is directly linked to the length from the higher point relatively to the green line but with the orientation of the red line.

21/ Deformation:

- The height ‘H’ is constant (1 m)
- The lengths I noted ‘L’ are constant (1 m)
- The depth is constant too (1 m)
- The volume of the container is constant at $1m^3$
- I deformed the container from a parallelepiped to a cube (parallelogram to a square in the side view).
- The volume is filled with $1m^3$ (bars and spheres), from start to end the container is filled

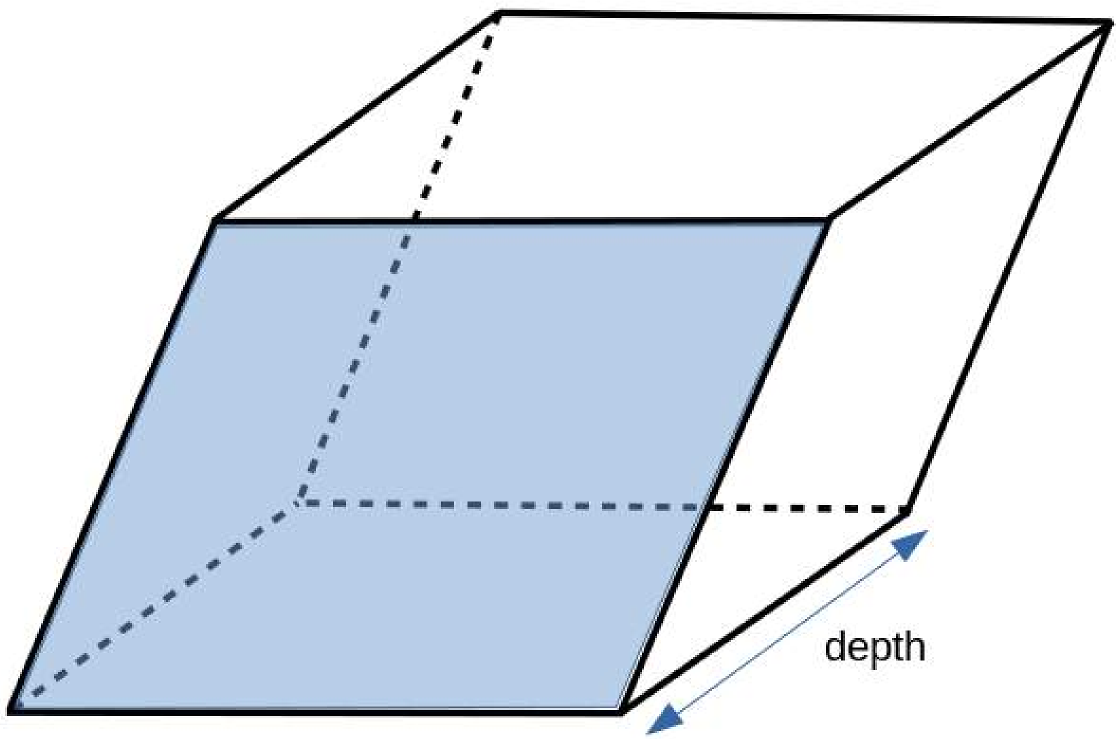
At start, the container is filled with near 1 m^3 of bars, near no spheres inside, just the necessary to have pressure between walls and bars. So, there is near 0 m^3 of spheres inside the container.
At final, there is 0.707 m^3 of the container filled with bars and $0.293m^3$ of the container filled with spheres (and their springs).

I drew only the side view, but for all the depth the cutting view is like the side view (parallelepiped).



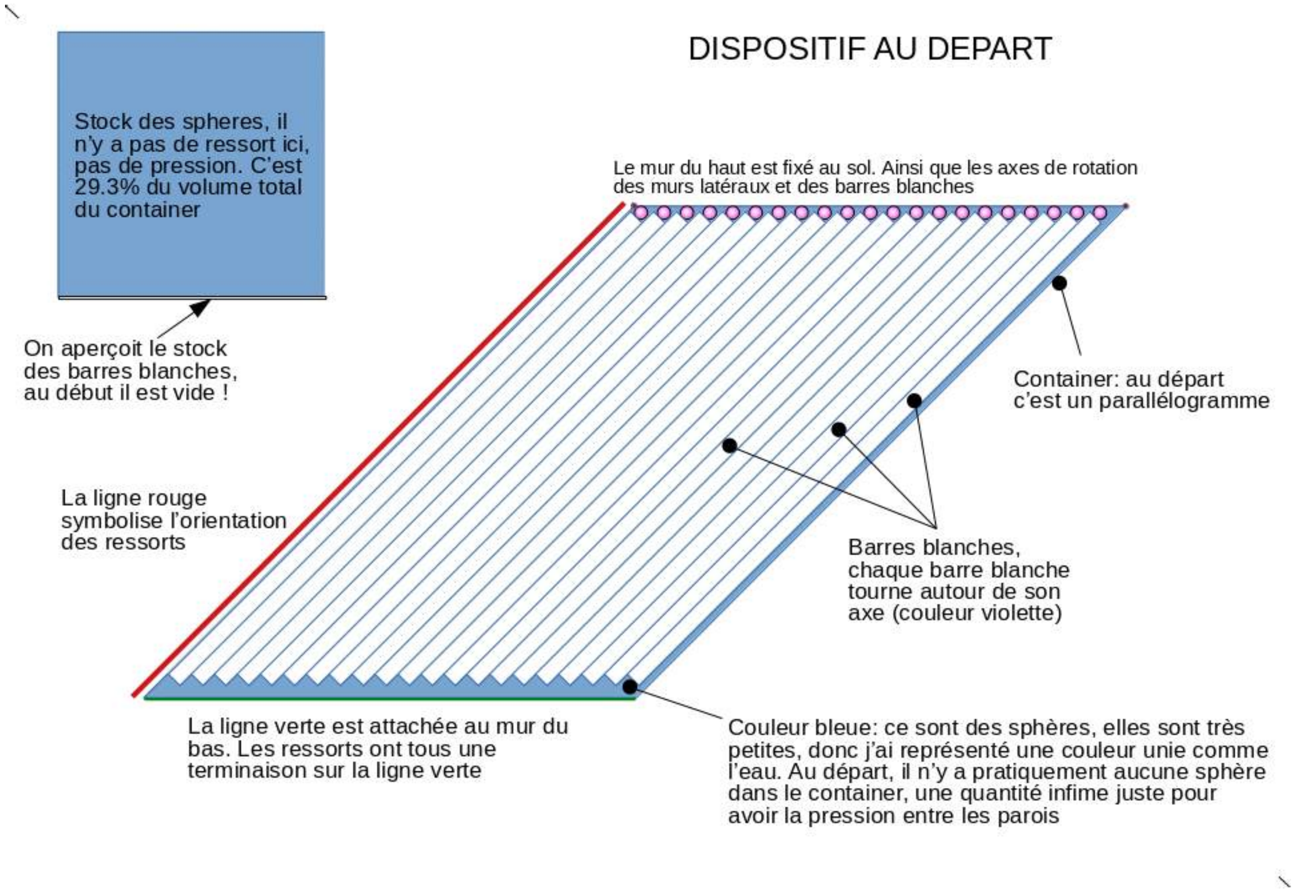
- The lengths H and L are constant
- The top of the container is fixed to the ground
- The lateral walls, left and right, turn respectively around A1 and A2
- The green line shows where the springs are attached. The green line is the bottom wall of the container
- The red line shows the orientation of the springs. Springs pull.
- The thickness of the white bars is constant

<u>The device is at start a parallelepiped and at final it is a cube:</u>



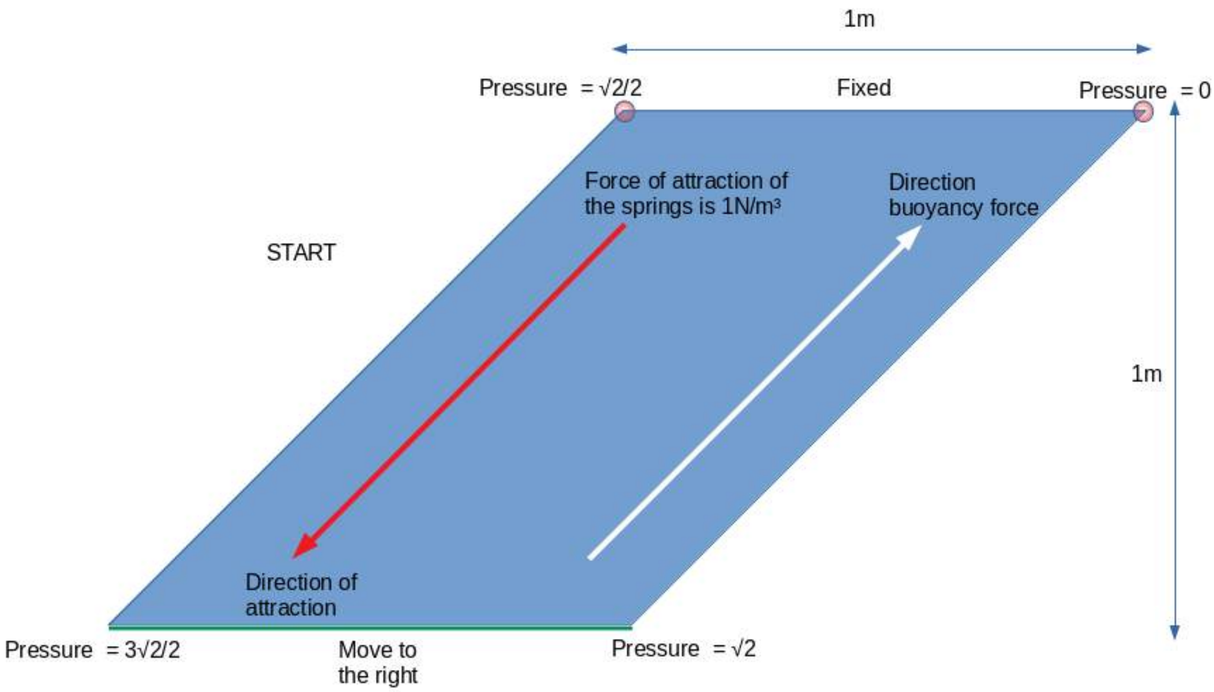
I drew only the blue face (2 dimensions) in that document.

I drew less bars to show details:

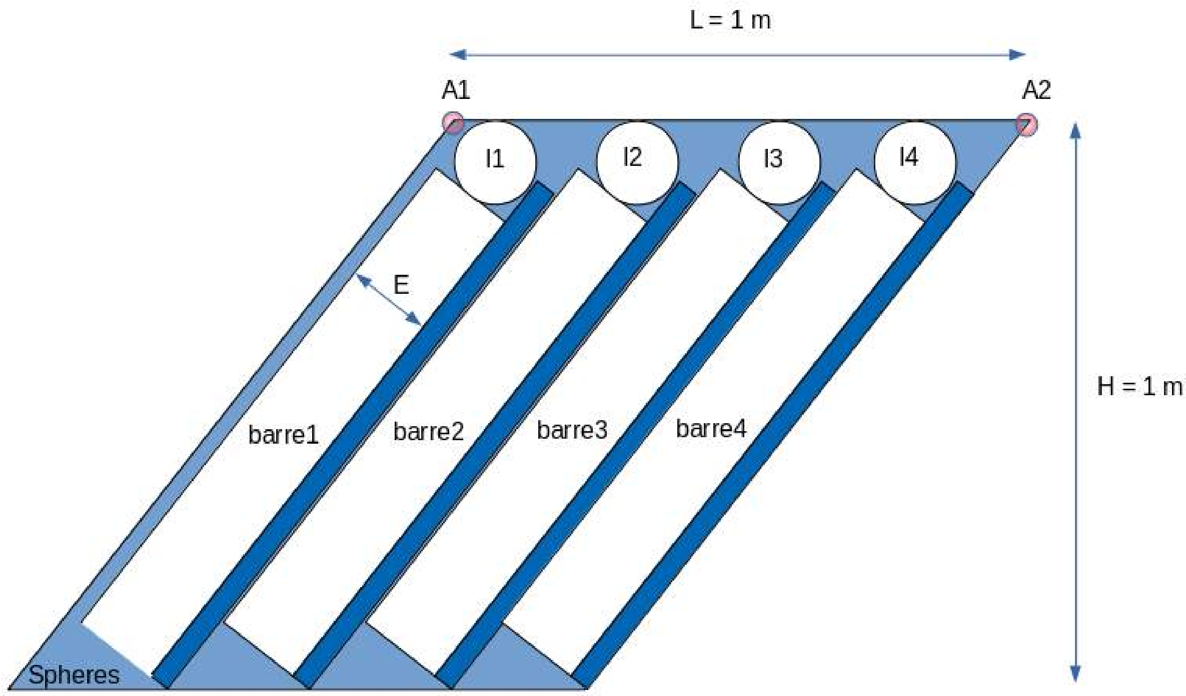


- This is the device at start
- It is possible to show the axes of rotation of the white bars in purple color (top)
- I drew the stockpile of the spheres and the parts of the bars, just to show at start, near all the spheres are outside the container. In the contrary, the white parts of the bars are inside the container, so the white stockpile at start is empty. The stockpiles have 1 m in depth.
- I drew in blue color the spheres, like I could do with water, because the spheres are very small like molecules of water

The direction of the attraction and the direction of the buoyancy force:



I drew the device with 4 bars, just to show more details. THE DEVICE IS NOT CALCULATED FOR 4 BARS ! BUT 1000 for example.



J'ai dessiné le dispositif avec 4 barres, c'est juste pour montrer correcterment les axes de rotation de chaque barre. La barre 1 tourne autour de l'axe I1, la barre 2 tourne autour de l'axe I2, etc.

J'ai dessiner en couleur bleue foncée là je rajoute les sphères lors de la déformation du dispositif (barres comprises). De l'espace apparait entre les barres lorsqu'elles se mettent à tourner. Bien entendu il faut réduire leur longueur par le bas.

Notez que la largeur E de chaque barre est toujours constante.

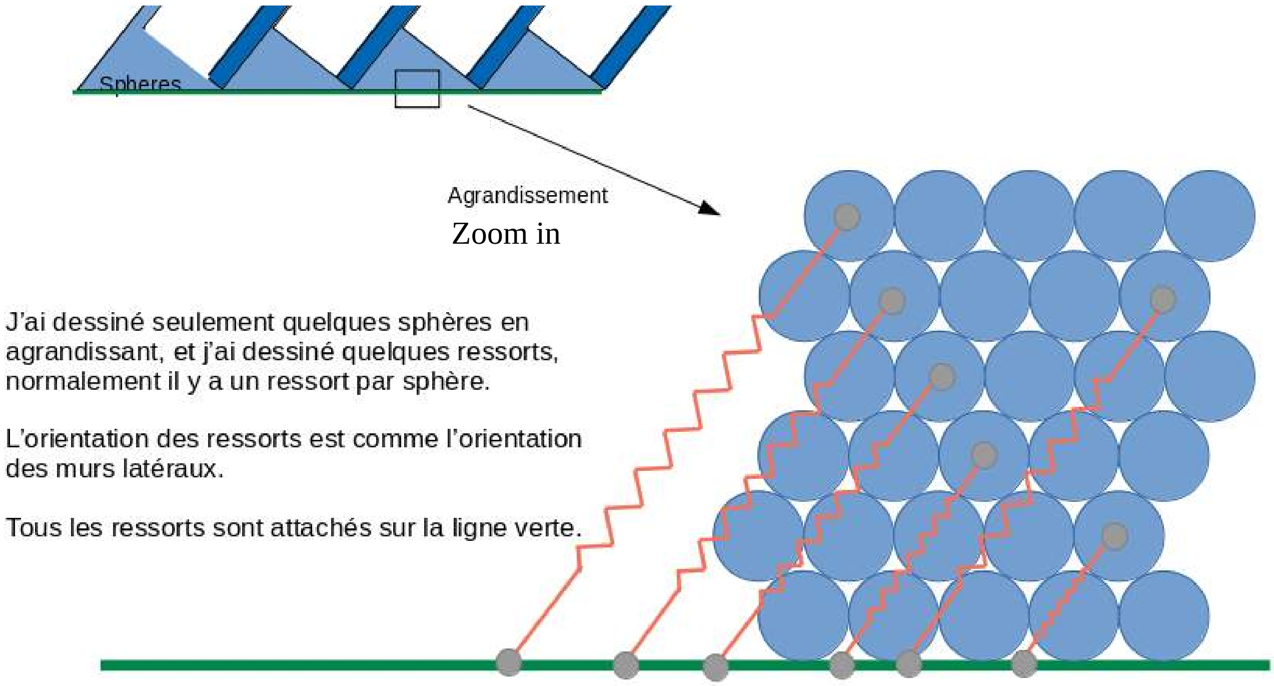
- Each bar rotates around its axis of rotation: barre1 rotates around the axis I1, barre2 around I2, etc.
- The thickness of each bar E is constant
- I drew in dark blue the space where I move in the spheres when the device is deformed

Note, at each time, the orientation of:

- lateral walls
- white bars
- springs

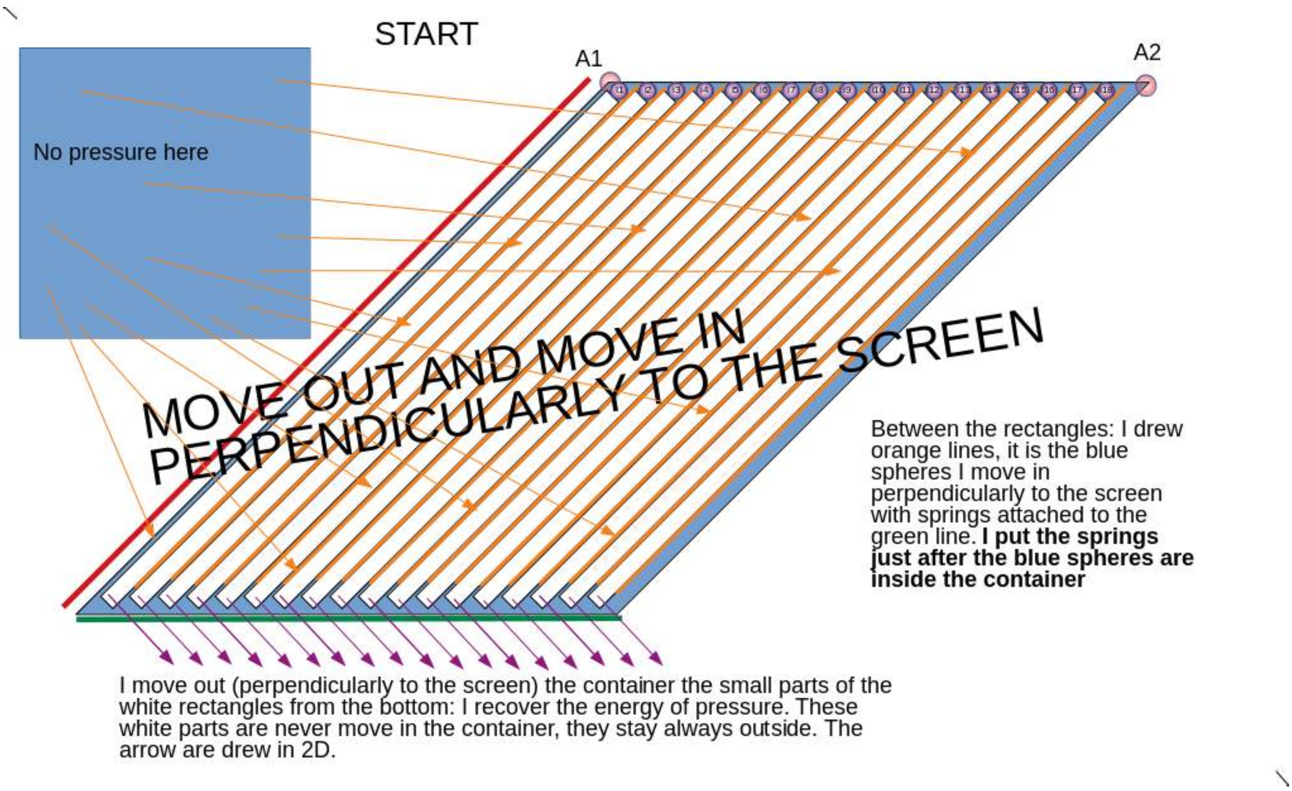
Is the same

I drew more details at the angle 53°:

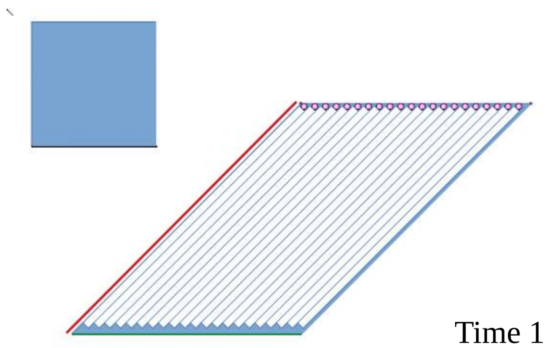


- I drew only few spheres, imagine the volume of each sphere like 1e-15m³ or less
- I drew few springs, EACH SPHERE HAS A SPRING
- It is possible to watch where the springs are attached: the gray dots. Note, the gray dots are fixed on the green line when the device is deformed and each spring is always on the same sphere.
- The orientation of the springs follows the orientation of the lateral walls

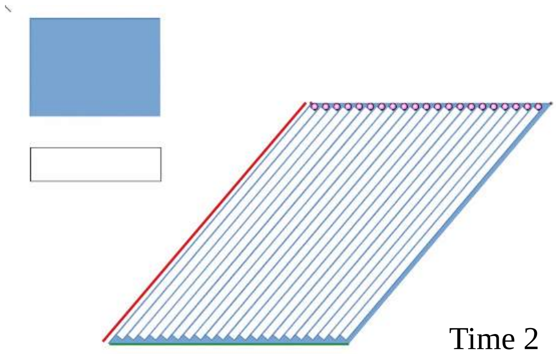
I drew where I move out the white parts of the bars and where I move in the blue spheres:



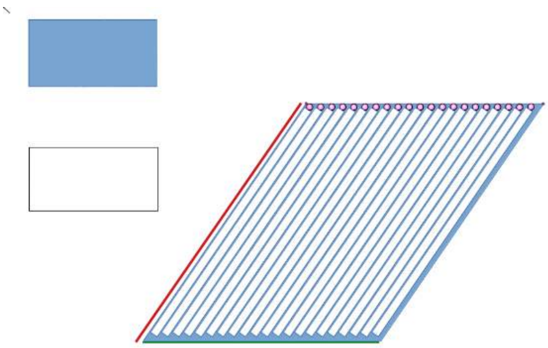
<u>I drew different positions of the device from start to end:</u>



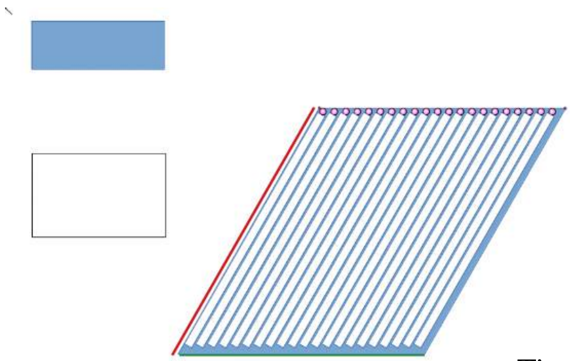
Time 1



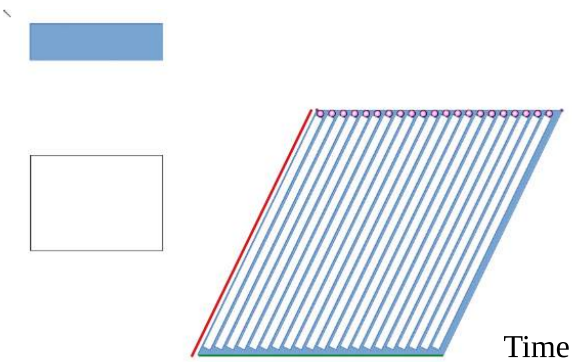
Time 2



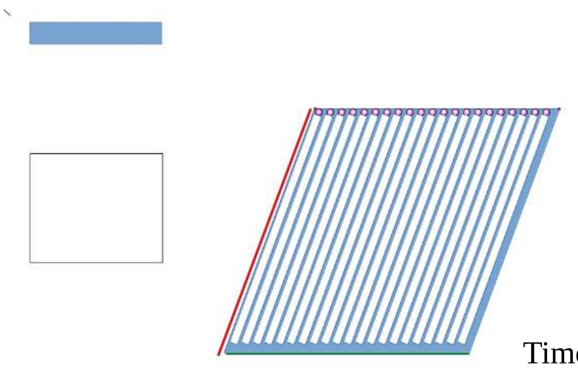
Time 3



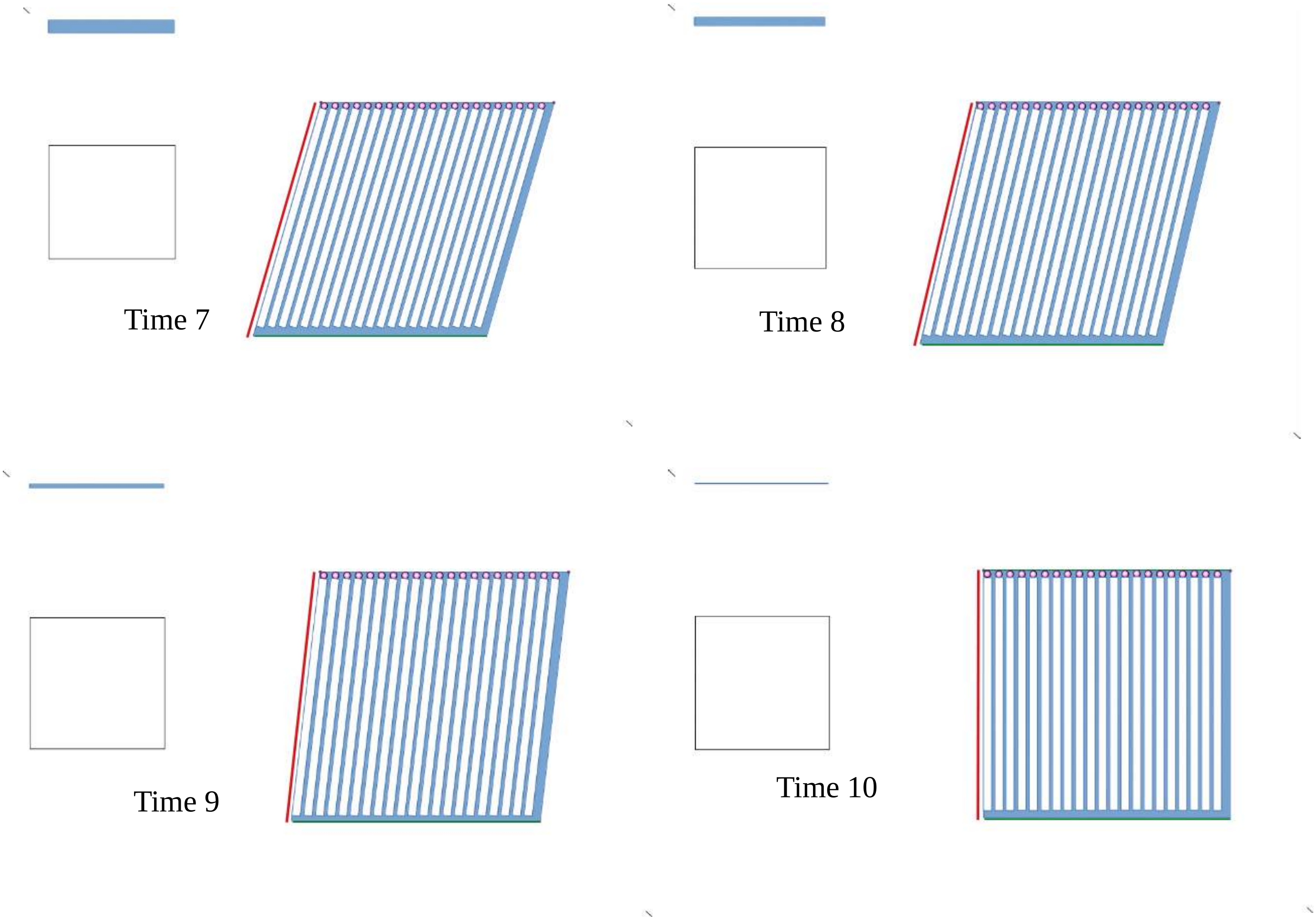
Time 4



Time 5

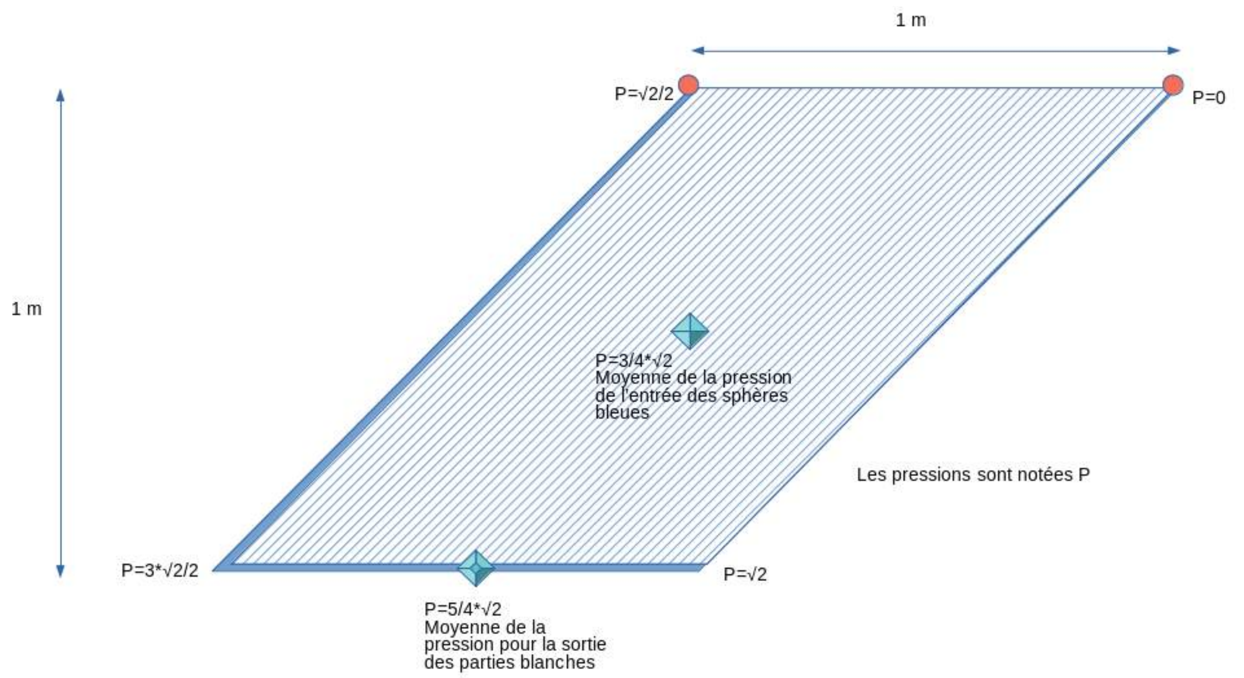


Time 6



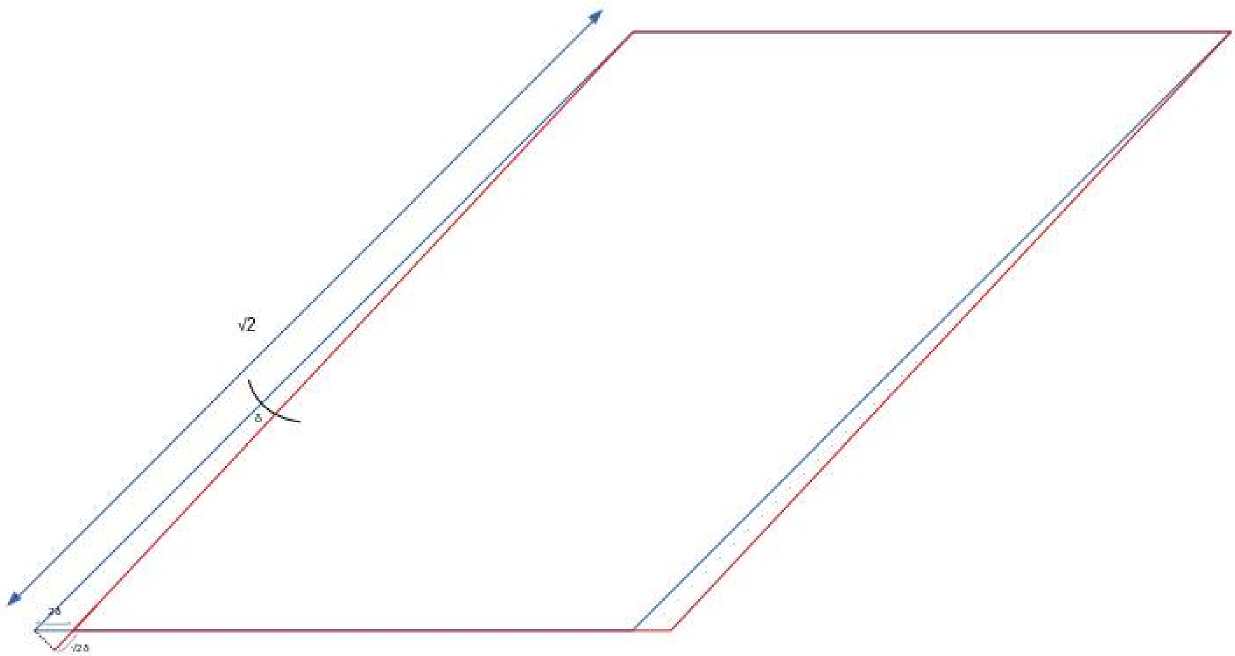
At Time1, the device is at start. And it is deformed more and more, at Time2 and after at Time3, etc. At final, the device is at time Time10. Note, the area I drew (volume) of the stockpile, the 0.293m³ of the spheres move inside the container, in the contrary, the stockpile of the parts of the bars move out the container to go inside the white stockpile.

A/ Calculations for a small angle δ of rotation around the position Θ:



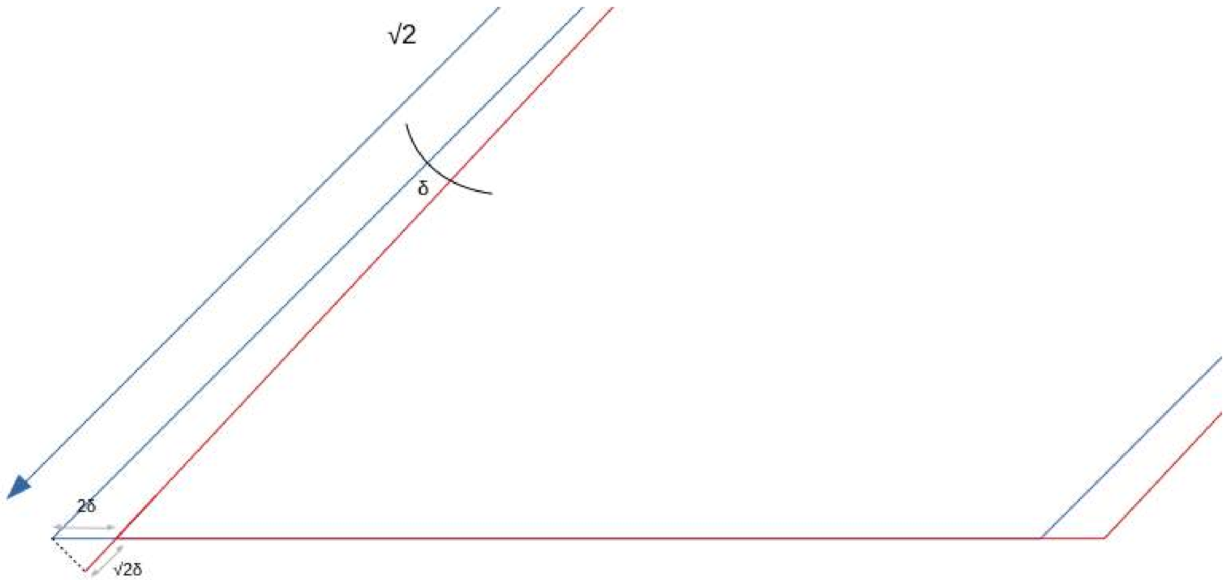
I drew the device at Θ=45°, but there is a problem of approximation with the method, because at 45° if I reduce the angle δ then the number of spheres decreases, like the forces from the springs on the green line, so the result is more and more small like the error. If I take another angle Θ, even 5° there is well a difference.

<u>An example, the device from 45° to 46°:</u>

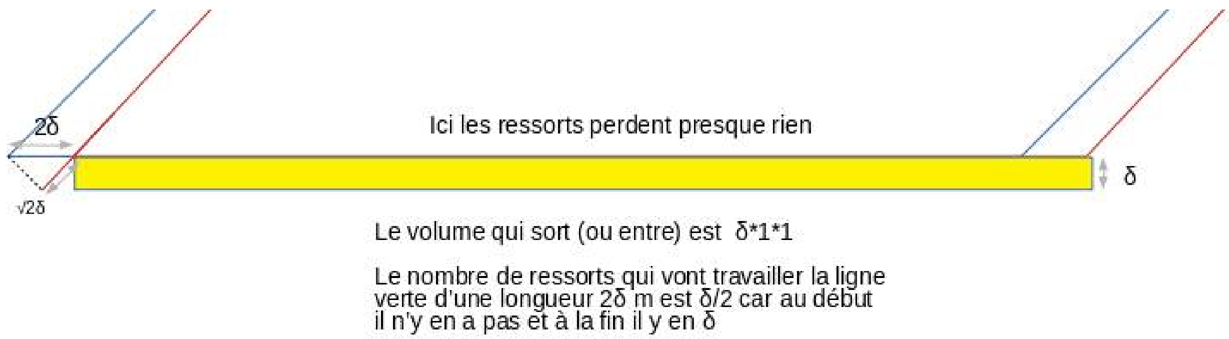


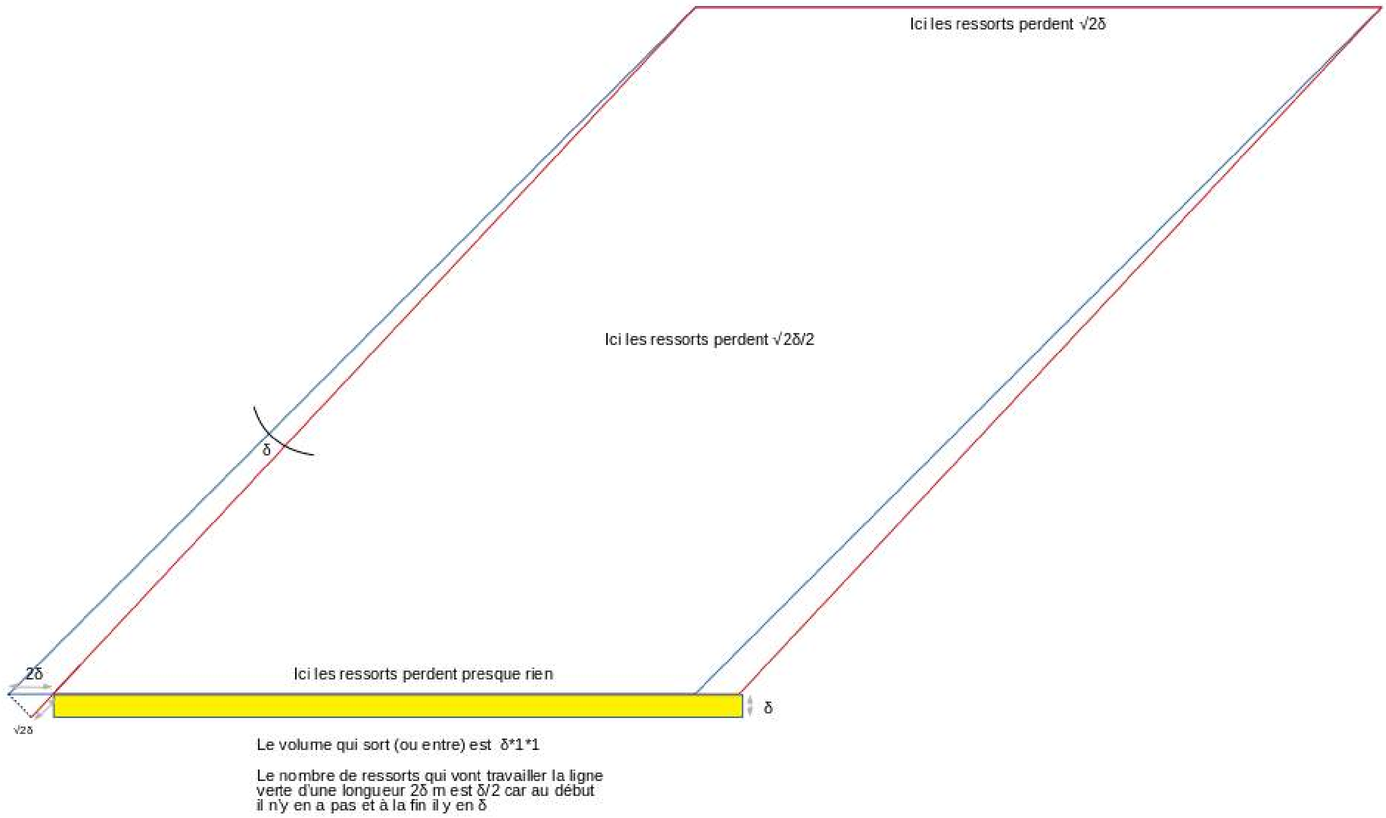
I drew for $\delta = 1°$ but it could be smaller

Details:



With the volume that moves out:




Ici les ressorts perdent √2δ
Ici les ressorts perdent √2δ/2
δ
2δ
Ici les ressorts perdent presque rien
δ
√2δ
Le volume qui sort (ou entre) est δ*1*1
Le nombre de ressorts qui vont travailler la ligne verte d'une longueur 2δ m est δ/2 car au début il n'y en a pas et à la fin il y en δ

<u>Calculations:</u> with the depth of the device = 1 m

<u>Work to rotate the lateral walls:</u>

For a same horizontal, the difference of pressure between the left wall and the right wall is ps = cos(Θ) Pa.

Angle of rotation: δ

mean length of the segment : (1/sin(Θ)+1/sin(Θ- δ))/2 m

Mean radius where the force is rs: (1/sin(Θ)+1/sin(Θ- δ))/4 m.

Mean pressure : (cos(Θ)+cos(Θ - δ))/2 Pa

The force is fs = ls*ps*1 = (1/sin(Θ)+1/sin(Θ- δ))/2 * (cos(Θ)+cos(Θ - δ))/2 N

The moment is fs*rs = (1/sin(Θ)+1/sin(Θ- δ))/4 * (1/sin(Θ)+1/sin(Θ- δ))/2 * (cos(Θ)+cos(Θ - δ)) / 2 Nm

The work is: fs*rs*δ = - ((1/sin(Θ)+1/sin(Θ - δ))/4 * (1/sin(Θ)+1/sin(Θ- δ))/2 * (cos(Θ)+cos(Θ - δ))/2) δ J

<u>Work recovered to move out the white parts and move in the blue spheres:</u>

The volume out = the volume in

Volume is : cos(Θ)/sin(Θ) * δ * 1 * 1 = cos(Θ)/sin(Θ) * δ m^3 (look at the figure)

Mean difference of pressure: (1/(2*cos(Θ)) + 1/(2*cos(Θ- δ)))/2 Pa

Work recovered is: cos(Θ)/sin(Θ) * (1/(2*sin(Θ)) + 1/(2*sin(Θ- δ))) / 2 * δ J

<u>Potential energy lost by springs:</u>

Mean lost of length of the springs: (1/sin(Θ) -1/(Θ- δ)) /2 m

Sum of the force from the springs : (1/sin(45°))-1/(sin(Θ)) / √2 N

The energy lost by the springs is: - ((1/sin(Θ) -1/(Θ - δ)) /2) * ((1/sin(45°))-1/(sin(Θ)) / √2) J

<u>The work won by the green line:</u>

She moves of: (1/tan(Θ) – 1/tan(Θ - δ)) m

The force of the springs is: (1/sin(45°))-1/(sin(Θ)) / √2 N

The angle of the force is Θ then the work is reduced of $\cos(\Theta)$

Then the work is : $(1/\tan(\Theta) - 1/\tan(\Theta - \delta)) * (1/\sin(45°))-1/(\sin(\Theta)) / \sqrt{2} * \cos(\Theta)$ J

Sum of energy:

$- | ((1/\sin(\Theta)+1/\sin(\Theta - \delta))/4 * (1/\sin(\Theta)+1/\sin(\Theta- \delta))/2 * (\cos(\Theta)+\cos(\Theta - \delta))/2) \delta |$
$+ | \cos(\Theta)/\sin(\Theta) * (1/(2*\sin(\Theta)) + 1/(2*\sin(\Theta- \delta))) / 2 * \delta |$
$- | ((1/\sin(\Theta) -1/(\Theta - \delta)) /2) * ((1/\sin(45°))-1/(\sin(\Theta)) / \sqrt{2}) |$
$+ | (1/\tan(\Theta) - 1/\tan(\Theta - \delta)) * (1/\sin(45°))-1/(\sin(\Theta)) / \sqrt{2} * \cos(\Theta) |$

Different values of Θ and δ :

Θ°	**δ°**	**Diff=| difference energy out/in less lateral walls |**	**Sum=Sum of energy**	**Sum/diff**
48	0.01	1.85e-8	2.57e-6	138
50	0.01	1.69e-8	3.68e-6	217
60	0.01	1.17e-8	5.34e-6	456
70	0.01	9.17e-9	4.19e-6	456
80	0.01	7.97e-9	2.21e-6	277
48	1	1.89e-4	3.65e-4	2
50	1	1.72e-4	4.75e-4	2.8
60	1	1.18e-4	6.25e-4	5.3
70	1	9.24e-5	4.95e-4	5.5
80	1	8e-5	2.88e-4	3.6

Sum/diff is inversely proportional at δ. If δ=0.001° then sum/diff is divided by 10 in comparison of δ=0.01° so the error of calculations is well reduced.

Note: the work to have the exact orientation of the springs:

I can also calculate the energy to move an end of each spring on the green line:

I have N white bar, then the thickness of one bar is $1/N/\sqrt{2}$ m.
The distance corrected is $(\sqrt{2}-1)/N/\sqrt{2}$ m

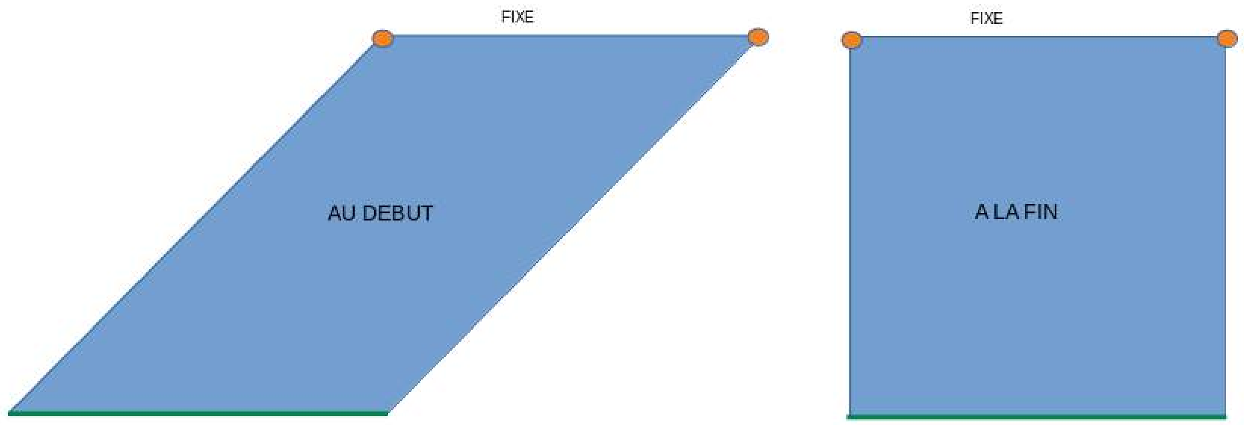
The force of all springs is affected by a coefficient $(\sqrt{2}-1)$, and I need to mean because at start there is near 0 springs inside the container, so the force of the springs is $(\sqrt{2}-1)/2*1$ N because the all volume of the container is 1 N.

The work to change the orientation is $(\sqrt{2}-1)/2 * 1/N/\sqrt{2} = k/N$ J, it is important to watch the work is divided by N, so I can reduce it and in theory it could be near 0 J.

B/ Work for a big angle of rotation from 45° to 90°:

I studied 2 devices before, to show some results.

Case 1/ The device is filled of spheres, nothing moves out/in



It is the same container of 1 m³

a) The lateral walls needs the energy (result negatif, in J)

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \frac{\cos(x)}{2\sin^2(x)}\,dx = \frac{1}{\sqrt{2}} - \frac{1}{2} \approx 0.20711$$

Or with double integrals

Left walls (negatif in J):

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \int_0^{\frac{1}{\sin(y)}} \frac{\cos(y) + \frac{1}{2\sin(y)}}{2\sin(y)}\,dx\,dy = \frac{1}{8}\left(-4 + 5\sqrt{2} + \coth^{-1}\left(\sqrt{2}\right)\right) \approx 0.494055$$

Right wall (J):

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \int_0^{\frac{1}{\sin(y)}} \frac{1}{((2\sin(y))\,2)\sin(y)}\,dx\,dy = \frac{1}{8}\left(\sqrt{2} + \coth^{-1}\left(\sqrt{2}\right)\right) \approx 0.286948$$

b) energy lost by springs:

At start, the mean length of the springs is √2/2 m
At final, the mean length of the springs is 0.5 m
The mean force of the springs is 1N/m³*1m³ = 1 N

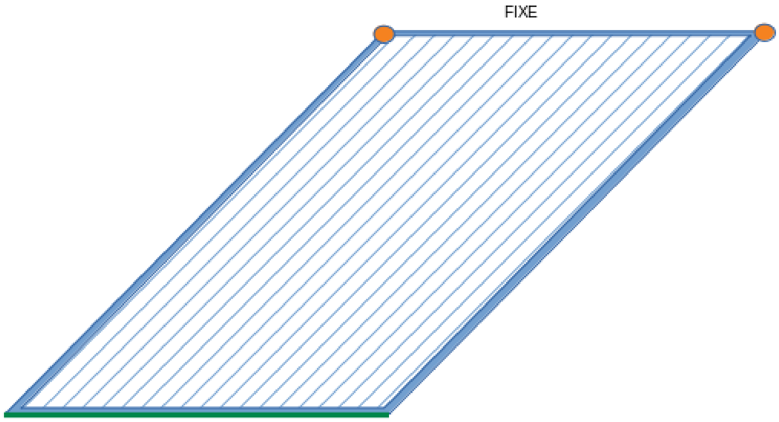
The energy lost by the springs is : 1/2-√2/2 = -0.20711 J

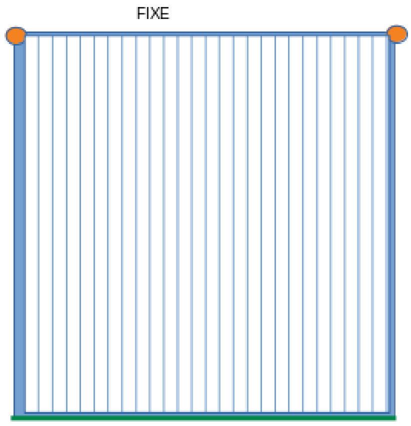
c) Energy won by the green line (J):

$$\int_0^1 \cos\left(\tan^{-1}\left(\frac{1}{1-x}\right)\right) dx = \sqrt{2} - 1 \approx 0.41421$$

Sum of energy: it is well at 0. The green line won that the springs and the lateral walls lost.

Case 2/ Near no spheres from start to end, just the white bars:





I move out the white parts from the bottom and I move in the white parts between the bars.

a) Lateral walls

The same than the case 1: 1/2-√2/2 = -0.20711 J

b) Energy lost by springs

There is near no spheres, so near no springs, so near no energy lost from the springs. It is 0 J.

c) Energy won from move out/in the white parts (J):

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \frac{\cos(x)}{(2\sin(x))\sin(x)}\,dx = \frac{1}{\sqrt{2}} - \frac{1}{2} \approx 0.20711$$

The sum of energy is well at 0 too. There is near no torques on the bars IF the number of bars is high. I supposed here I have a big number of bars in the contrary there is a work from the torques on each bar. Like the work of the torque is divided by the number of bars, in theory that work is near 0.

Case 3/ The device I studied, here the sum of energy is not conserved

a) The lateral walls need the energy 1/2-√2/2 = -0.20711 J

b) Move out the white parts and move in spheres gives the energy : √2/2-1/2 = 0.20711 J

c) Energy lost by the springs (negative, J):

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \left(1 - \frac{1}{\sin(x)\sqrt{2}}\right)\cos(x)\,dx = \frac{1}{4}\left(4 - 2\sqrt{2} - \sqrt{2}\,\log(2)\right) \approx 0.047829$$

d) energy won by the green line (J)

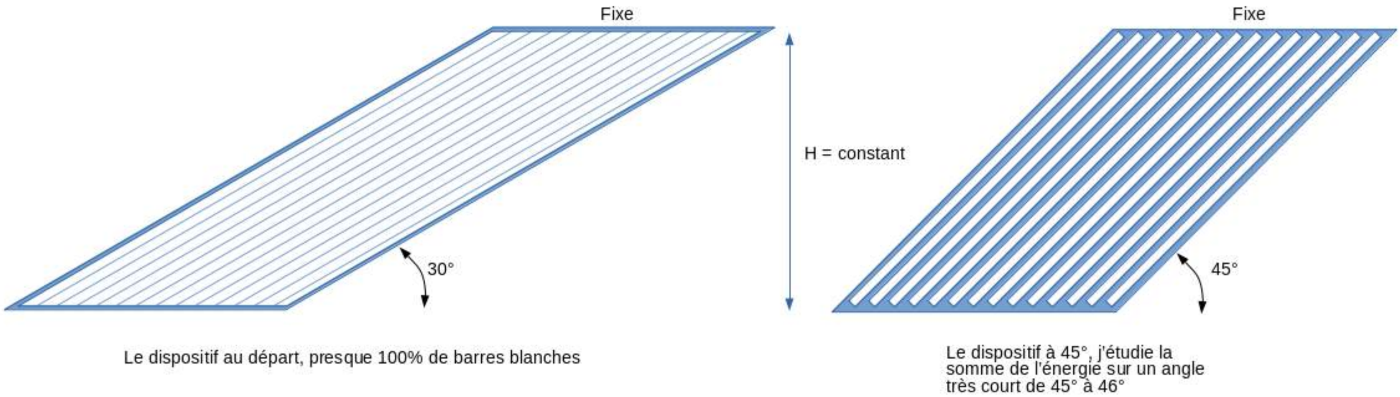
$$\int_0^1 \cos\left(\tan^{-1}\left(\frac{1}{1-x}\right)\right)\left(1 - \frac{1}{\sqrt{2}\,\sin\left(\tan^{-1}\left(\frac{1}{1-x}\right)\right)}\right)dx = \frac{3}{2\sqrt{2}} - 1 \approx 0.0607$$

The sum of energy is **not** at 0.

Some ameliorations:

1/ Modification of the device to be more efficient at 45°

At 45°, the last device is not efficient. But it is possible to change the angle at start where the device is filled of white bars, 30° for example:



For a small angle of rotation δ around 45° the energies are:

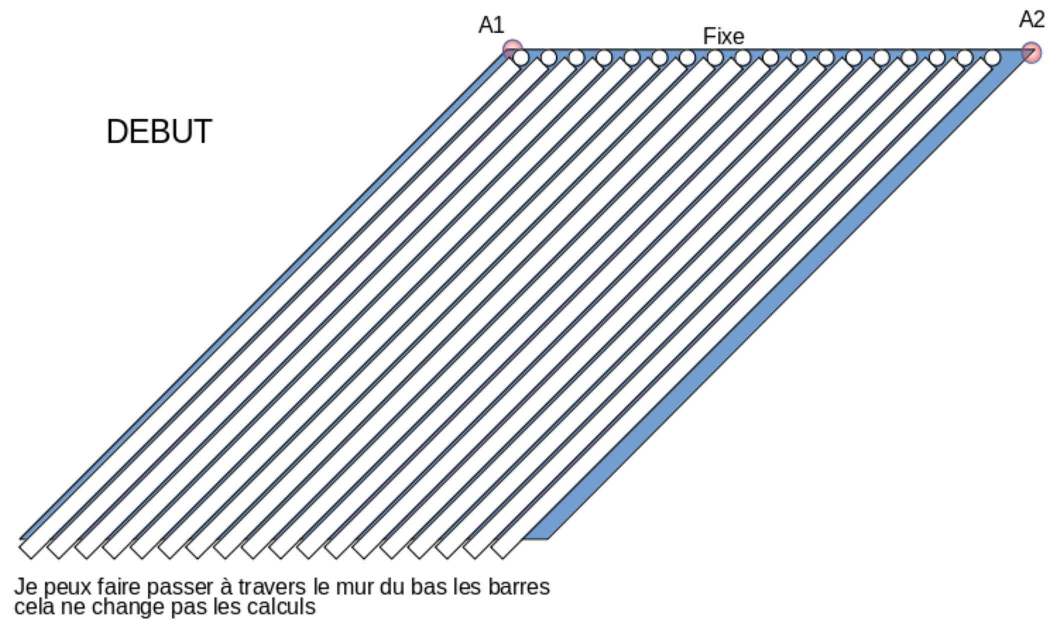
Lateral walls = $-\sqrt{2}/2*\delta$ J
Move out/in = $\sqrt{2}/2*\delta$ J
Potential energy lost from springs = $-\sqrt{2}*\delta/2*0.292$ J
Energy won by green line = $0.292*2*\delta*\sqrt{2}/2 = 0.292*\delta*\sqrt{2}$ J

Sum of energy $\sqrt{2}*\delta/2*0.292$ J

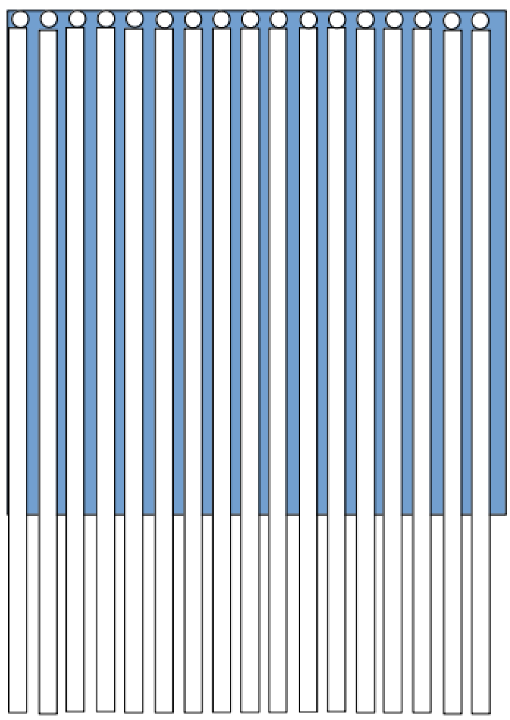
2/ Don't move out the white parts

Instead of move out, I can do that:

At start:



<u>At final:</u>



I pass the bars through the bottom wall.

<u>3/ Move in the spheres:</u>

Instead of move in the spheres perpendicularly to the screen, I can move in the spheres from the white bars. It is easy, one end of each bar is near the axis of rotation and the bars are empty so it is possible in practice.

<u>4/ Volume of the springs:</u>

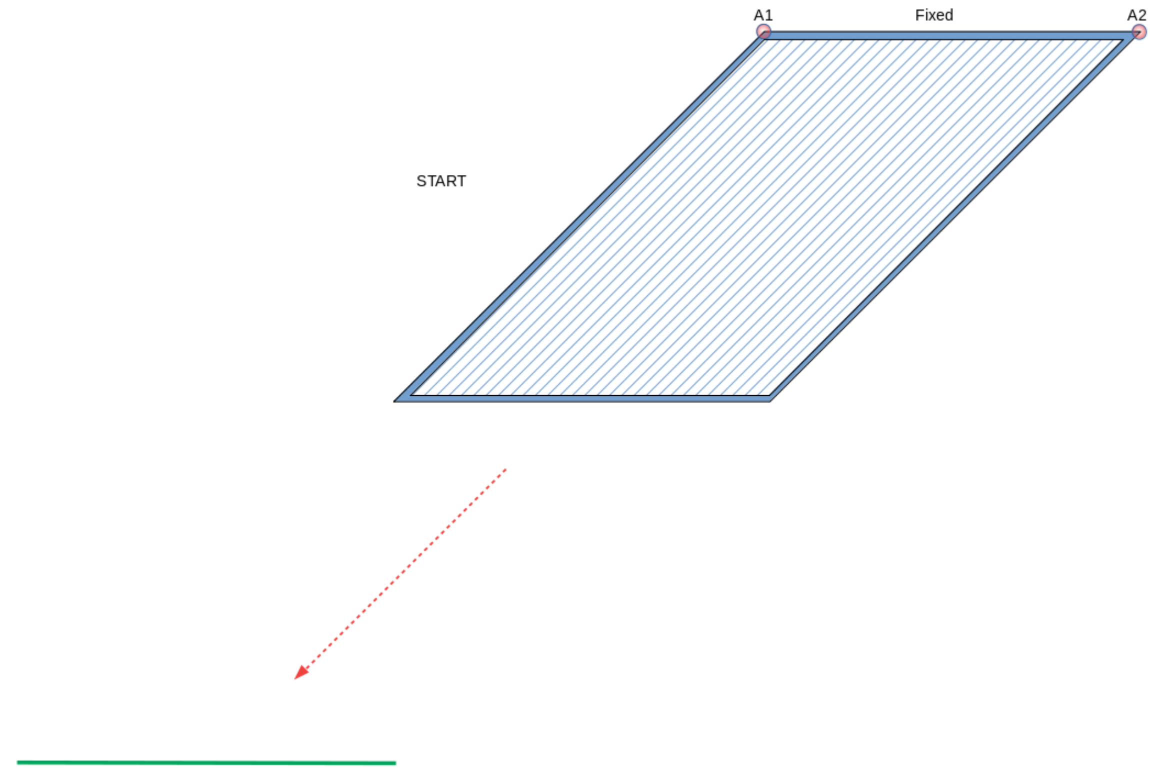
I can change the manner to attract the spheres. I can attract one sphere from the previous. The springs near the green line are stronger than at top, but it doesn't change the potential energy.

<u>5/ The gradient of pressure in reality:</u>

The device is mechanical but in reality to create the energy you need to use something else than mechanics to have the gradient of pressure, like electromagnetism for example.

<u>6/ The problem of the orientation of the springs</u>

It is possible to let the springs attached on the green line if the orientation of the springs are near the same with an angle near the lateral walls. For that, it is possible to change the position of the green line. The next 2 images show how to change the position of the green line. That doesn't change the sum of the energy.



The green line can be lower like that the orientation of the springs are near the same