Centripetal force (quantify-measurements)

General objective:

To answer an idea from children about centripetal force - if the weight more light goes upper then the heaviest, it's because centripetal force on light weight is more important- we must try to measure these centripetal force apply on the two weights.

Special objective:

Show graphicly with diagramm the centripetal forces, and the gravity forces and the result of the two assemblied forces and compare these two forces to know what happen exactly in a such situation.

Useful material

Experiment:

- a peace of wood for engine
- two peaces with different weight
- string
- a scale
- a camera for pictures
- a white paper lightly tranparent
- pencils, instruments for geometry

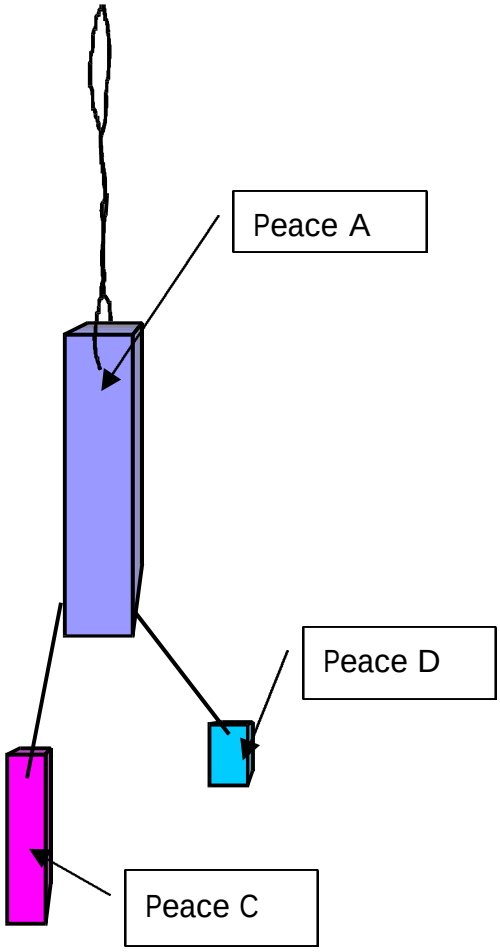
Experimental protocol:

Again last experience (docment on contripetal force): explain and drawing.

Two peaces C et D turn in the same way than peace A.

Peaces C et D go away from each other but the weightest goes upper than the heaviest.

They seem (C and D) turn less quickly than there were the same (same weight).



New experience:

The weight of two peaces C and D are exactly measured :

D: 1,7N (weight in Newton)
C: 5N

The strings who hang peaces C and D have the same lengh

Pupils ask next sentence:

Why peace D go upper than peace C?

They found an answer:
Peace D goes upper because it is less heavy than C and because centripetal force on it is more important (Kévin' s idea)

How can we measure exactly these forces?

Which forces are included in this rotation system?

Ideas:

Gravity force:
Each object has a mass and falls down when it is free.
This gravity force goes up to down, vertically.
String who hangs peaces keeps the same way than the force which pull it.
Even the forec who pull the string is'nt vertical, the string brings the same way than the force.
Drawing, the force is shown by an arrow in the same way than the force pull.

Centrifuge force (or centripetal in the opposite way) : it pulls outside the movement (sensitive in the arm, when pupil turn with the mass and with the elastic string.

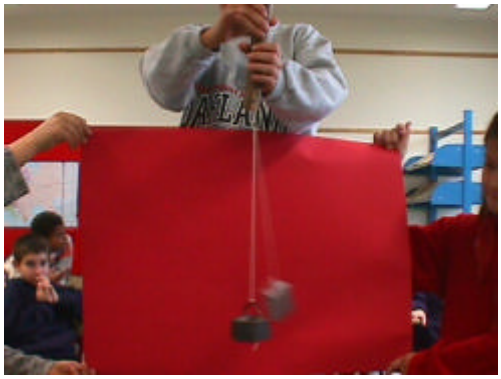
We can measure the difference between two weights: 5N et 1,7N
It's possible to draw by arrows the two weights: 5N → 10cm 1,7N → 3,4cm
They appear on parallel lines (verticals)

And now, how can we know where exactly are peaces C and D in rotation movement?
Chlidren's ideas:
→ put a peace of wood between C and D and measure it after (Léa's idea)
→ stop sudenly the rotation movementby the hands and take the measure after (Christilline)
These two ideas can't be realised if we want to measure exactly C and D in movement without outside intervention; then a third idea appears:
Take a picture with our numeric camera: after on the picture make measurements. (several pupils)

How to do:

A child: standing up on a chair (Pierre-Olivier)
A res screen (to see better strings and weights after).
A numéric camera
A cameraman. (Baptiste)

Documents overthre:
We can't see very well on this first picture:



Rotation movement not enough strong. The same for peace A.

2° picture:

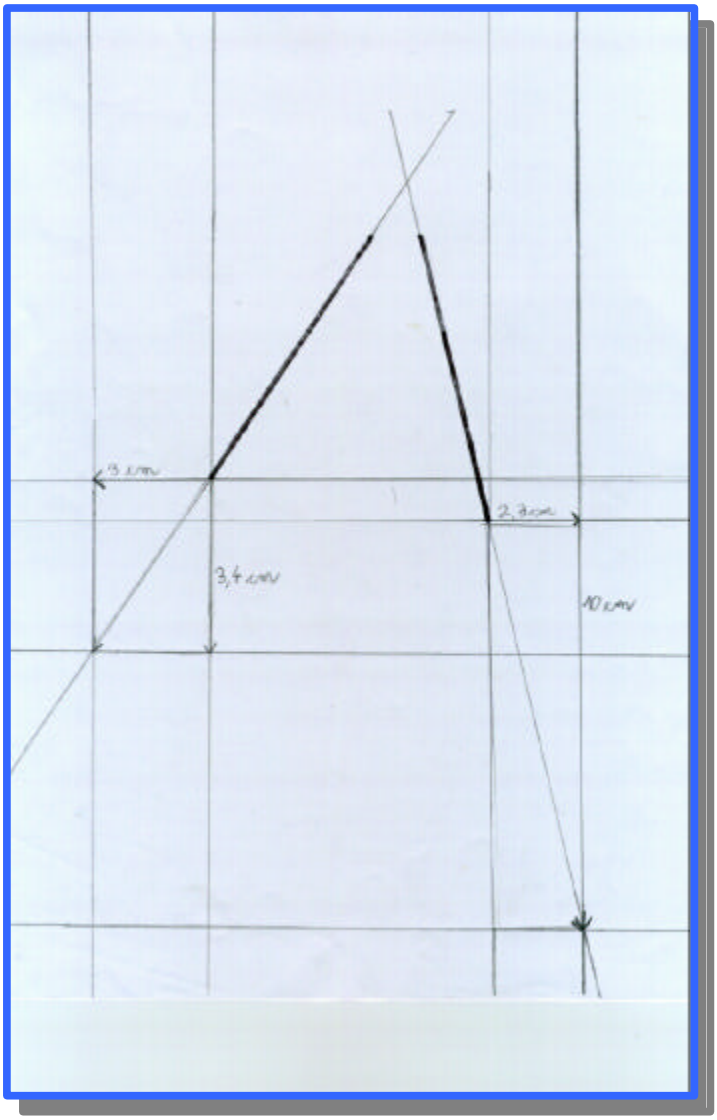
What we can see then:
Two weights enough separate. Strings straight.
A weight (the more light upper than the other)
Quick rotation of the all system.

How can we transcribe this picture and get a draw we can use for measurents??

Copy on a white paper the photocopy of this picture.
Next document:

Drawing on white paper :

Scan the Guillaume's document. You can see arrows who represent gravity (vertical and the same way than the (gravity) and by informations given and others pupils drawing centrifuge it's a real discussion physiciens and older centrifuge force, action, reaction: the explaination of centrifuge force- the children feel with rotation turning a ball around others or aroud lenghts are in the real forces geometry and to them, Guillaume find, built by force (I know that between scientists: centripetal force, that's why I keep outside force - because it's like when they play movement like their arms to jump their ankle)



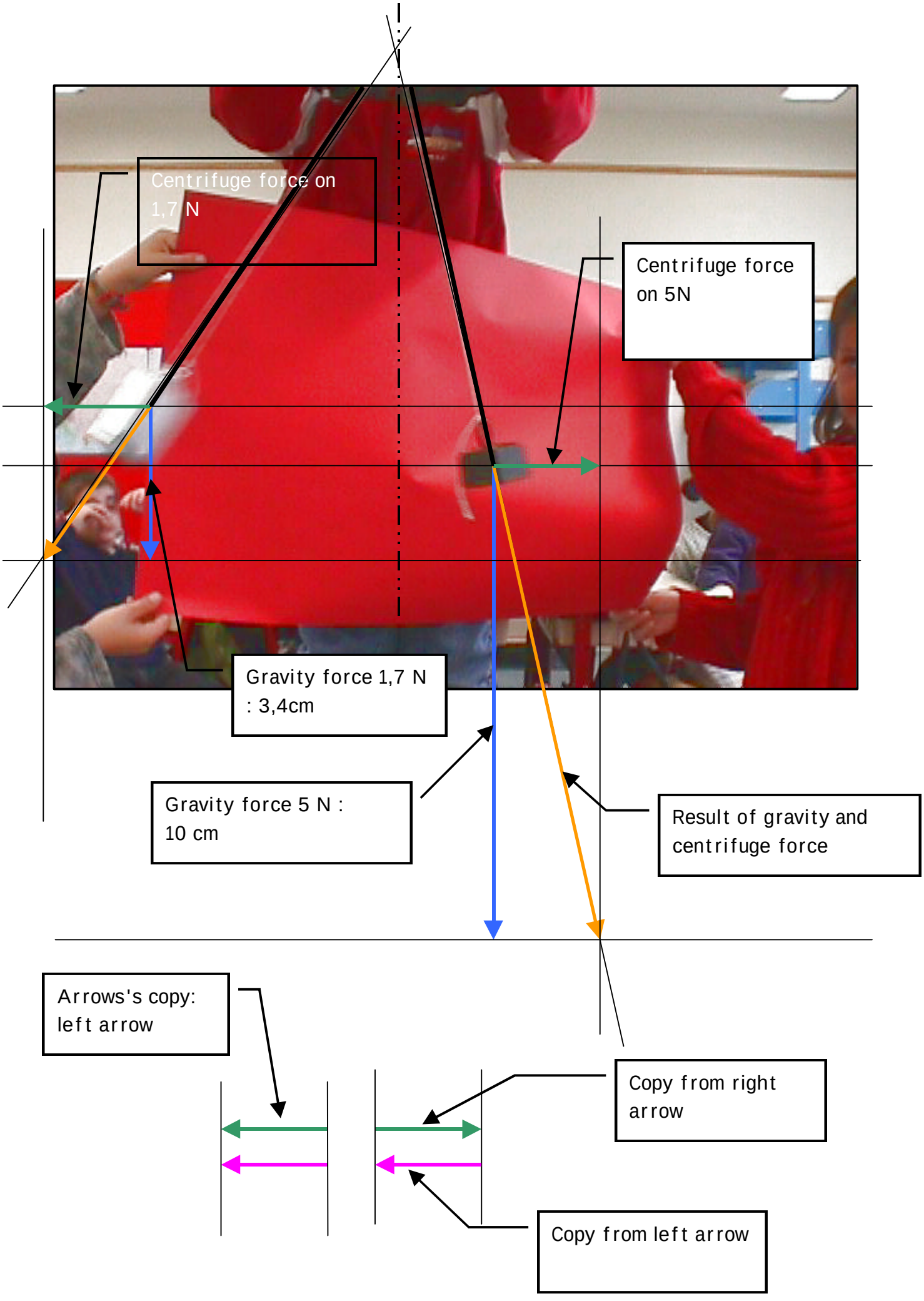
Statistics results from all pupils :

Prénoms	F1 (cm)	F2 (cm)
Arnaud	1,90	3,50
Guillaume	2,30	3,00
Mathieu	2,70	2,70
Thibaud	2,00	2,50
Marine	3,40	5,00
Rachel	1,50	2,10
Justine	1,00	2,00
Christilline	2,50	1,00
Emilie	2,60	1,80
Maxime	2,20	2,30
Olivier	1,70	4,00
Romuald	1,90	3,10
P Olivier	1,90	2,50
Baptiste	1,70	2,70
Cyril	1,90	4,60
Léa	2,40	2,30
Sophie	2,20	1,90
Béatrice	2,00	2,50
Laëtitia	2,70	2,50
Laura	2,00	2,10
Laure	2,50	2,00
Martin	1,10	1,40
Kévin	1,40	1,50
Stéphane	2,40	2,50
Angy	3,00	2,00
Moyenne	2,12	2,54

F1 : centri- force on weight 5 N

F2 centri-force on weight 1,7N

Statistics results seems to show that F1 and F2 are neraly the same, but F2 seems to be a little bit stronger than F1.
But, when I see all geometrics drawings, I find that they were not very exact and I want to show them what is the result when drawing is more precise. I get the numéric picture and I built with computer the next document.


Centrifuge force on 1,7 N
Centrifuge force on 5N
Gravity force 1,7 N : 3,4cm
Gravity force 5 N : 10 cm
Result of gravity and centrifuge force
Arrows's copy: left arrow
Copy from right arrow
Copy from left arrow

Two forces appears neraly the same: (centifuge force and centripetal force)

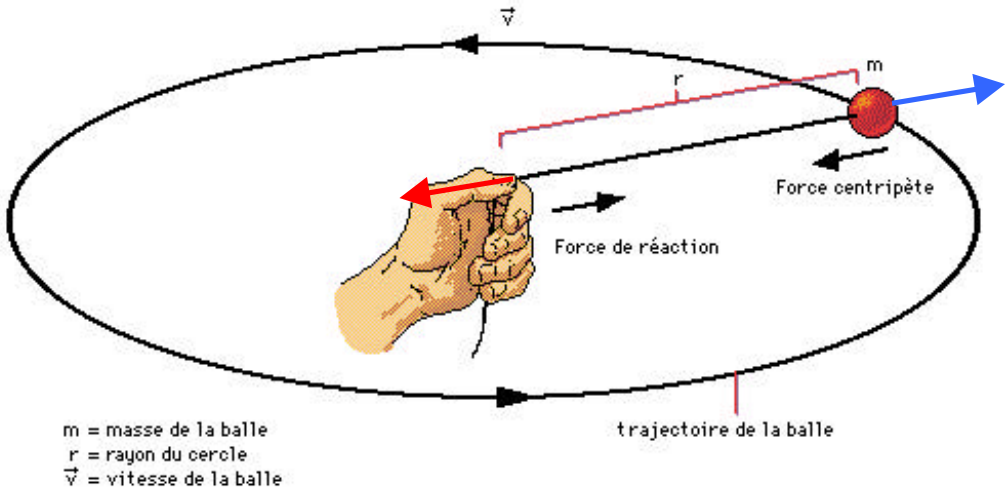
More questions and answers:

1) Why lighter weu=ight goes upper than the other?

2) After research in scientifics books, what can we think about these results and centrifuge or centripetal forces?

After reading informations on books, on multimedia, one representation can be the next (after questions and answers by and for pupils)

Encyclopedic document:



Force that we call centrifuge force

In the scientific literature, the intensity or centrifuge or centripetal force is next:

Where m is the mass of object V, speed of it and r the distance betwen the object and the center of rotation.

Force given by the arm to keep the ball

$$F = \frac{m \times v^2}{r}$$

Conclusions:

1- The lighter mass goes upper
2- Two forces in our system (two masses) are nearly equal?
   Yes, on our rawing document , or on our picture.

3- By formula, the centrifuge force should be more important on heavier mass:

$$F = \frac{m \times v^2}{r}$$

an exemple: v=5m/s et r=1m
F1 on heavier mass: F1=125 u
F2 on lighter mass: F2=42,5u
On peut donc en conclure que F1 > F2 because 125 > 42,5 and 5N > 1,7N

4- Our experiment is it thrue or false (Rachel)?
   Yes, because we have a picture of it

5- Why do we find nearly equivalent force (F1 and F2), masses are different (5N et 1,7N)

Centrifuge force depends on:
→ mass: it is different in our experiment(5N et 1,7N)
→ speed rotation: we don't know the measure, but…
→ radius of rotation movement:

New question:

How turn each object, each mass in our experiment?

New experiment:
One group of pupils count how many round must do mass 5N and an other group count roundsfor 1,7N.

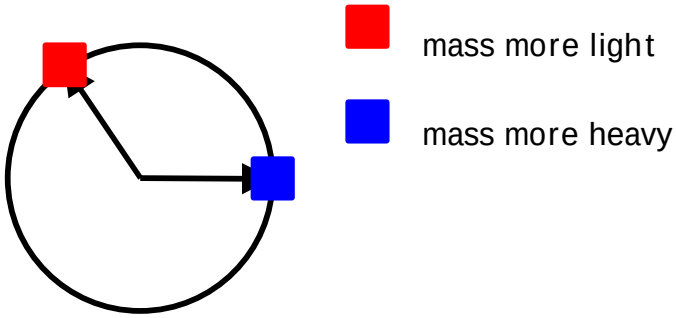
Resuls of this experiement: in 30 seconds,two masses turn the same: 23 rounds.

Baptiste' s Idea to try to understand better this system:

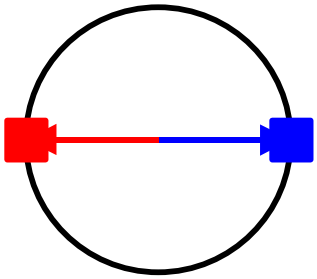
Imagine this experiment and looking it just under:

After this idea, several groups search and give answers or suppostions: you can find them in the next page:

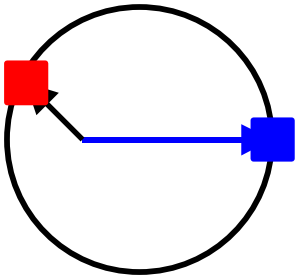
1rst Idea from Guillaume :



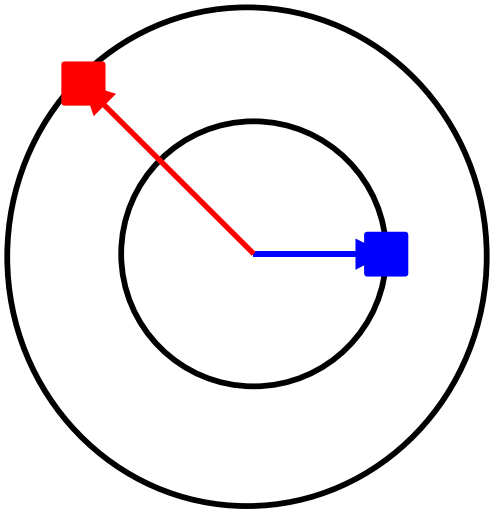
Kévin' idea:



2nd Guillaume'idea:

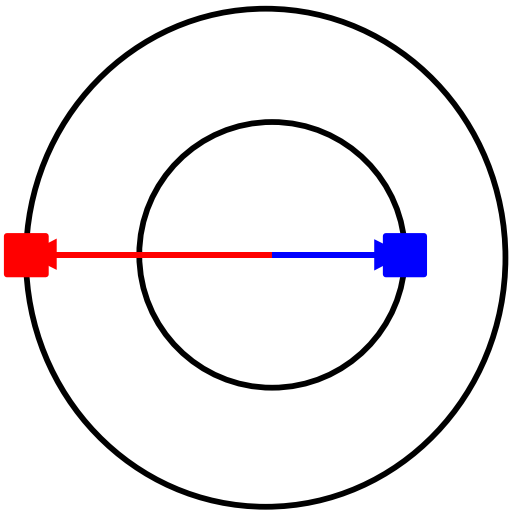


Thibaud's idea:



After exchanges and discussions between pupils each others, they find the next representation:

Final drawing:



Why this diagram?

Because two masses make the same nombers of rounds ans because they are opposite on two circles.
The heavier mass turn on a smaller circle than the lighter:
The lighter mass seems to go faster than the heavier because it is obliges to make much more distance than the heavier.

Why it seems to go faster?

It makes more distance (23 times the perimeter of the larger circle), it goes faster.

Finaly, ours results can be measure also by the law discovered by the scientists

To know:
Centrifuge force or centripetal force depends on rotation speed of the mass, the mass of the object and the distance between the mass and the rotation's center.

Now, we must see again solar system and find if it's the same for nine planets and the center of this system: the sun.

Pupils from Cm2 de Le Meux
And their teacher: Gérard CLAVET.