DESCRIPTION OF VARIOUS ROTATIONS

1. THE CENTRIFUGE

(the movement of the water and the laundry placed inside)

2. THE BALL THAT TURNS AROUND AN AXLE

(the movement of a ball hanging by a wire and driven by a rotating shaft)

3. THE EARTH THAT TURNS AROUND THE SUN

1. THE CENTRIFUGE

Everyone knows the principle of the centrifuge which is used in the washing machine or drier in the house.

Centrifuge comes from ‘centrifugal’ that just means 'which distances from the center.'

The centrifuge she proves the existence of centrifugal force?

This is what we'll see ...

A fundamental principle ...

A fundamental principle of physics (that is the first law of Newton, ADILCA see the folder '*Isaac Newton*') provides that the normal trajectory of a moving body is straight in nature.

This natural path can only be deflected by a transverse force. The concept of force follows from the previous principle: a force is any cause capable of deflecting a mass trajectory.

There are two types of forces corresponding to this definition: the gravitational force acting at a distance and the guiding force that acts by contact.

These laws are the foundation of modern physics, they were discovered and formulated by the English physicist Isaac Newton in 1666.

How does a centrifuge?

A centrifuge consists of a drum, a kind of hollow cylinder whose surface is perforated with holes for passing water, and an electric motor. When driven by the electric motor, the drum is driven with a rotational movement.

In its movement of rotation, the drum forces the wet laundry placed inside to describe a circular path.

According to Newton's law, the laundry in motion should take a straight path. If in a circle, it is because it is constantly subjected to the guiding force that carries the drum by contact. This force is centripetal direction (see ADILCA folder '*centripetal force*').

No centrifugal force of nature therefore acts on the machine, at any time whatsoever.

The drainage

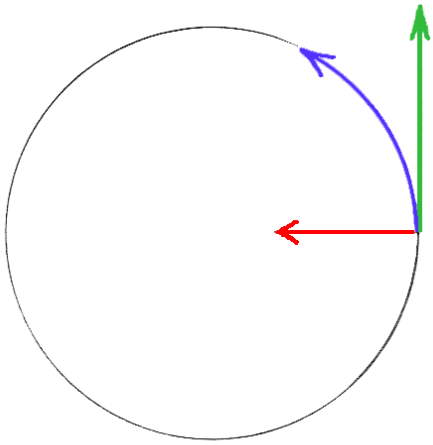
How the water leaves the drum?

It has been said that the drum is a cylinder with holes. The machine can communicate a guiding force to water molecules only in contact with the drum. When water molecules reach the holes, the guiding force is zero, so they immediately adopt a straight path that leads them to the outside of the drum.

This trajectory is not radial, that is to say in the extension of the radius, but tangential, i.e. perpendicular to the radius of the drum. So, if the water exits the drum, it is because of a default guiding force and not because of the centrifugal force.

To be precise, the trajectory of the water molecules is perfectly straight as when they leave the drum, but gradually this path is influenced by the combined action of the force of gravity and the air resistance.

But no centrifugal force affects the water molecules at any time whatsoever, no more inside and outside of the drum.



Principle of the centrifuge

Wet laundry in a circle (blue arrow) through the guiding force (red arrow) exerted by the drum. Water leaves the drum on a straight line tangent to the radius (green arrow). Be careful not to add the force and trajectory vectors!

Conclusion

The centrifuge exists, but not the centrifugal force!

ASSOCIATION ADILCA www.adilca.com * * *

2. THE BALL THAT TURNS AROUND A AXE

Some 'pseudo-physicists'[1], probably anxious to come to the aid of the concept of centrifugal force, thought they could prove the existence of an imaginary force describing the rotational motion of a ball around an Axe! Wasted effort!

Abuse of the concept of centrifugal force comes under the manipulation or incompetence. Indeed, the centrifugal force being an imaginary force, we can and we must do without, whatever the nature of circular motion considered: centrifuge, ball held by a thread, festive fun ride, car, earth, etc.

If we cannot, it's because there is a 'bug' somewhere! For you to find it!

Description of the device

Imagine a device composed of a motor driving a vertical shaft with, at the end of the shaft, a thread holding a ball. At rest, a single force acts on the ball, it is its weight. The ball remains stationary because its weight is balanced by the tension of the yarn. The system is in equilibrium.

The rotary system

Let start the engine. Once the system begins to rotate, the equilibrium condition is no longer respected. Neglecting the acceleration phase[2], when the rotation speed is stabilized, the ball has moved away from the axis, it describes a circular path in a horizontal plane, the wire retains an angle relative to the vertical.

The Contenders

According to the fundamental principle of physics (Newton's first law, see ADILCA folder '*Isaac Newton*'), the ball in motion should describe a straight path. If it does not, it is because she is constantly subjected to a force which imposes this circular path.

This force is the centripetal force! It is so named because it is directed toward the axis of rotation, it is exerted on the ball through the wire[3].

Contrary to a widespread error, the system is not in balance, otherwise how to explain the circular motion?

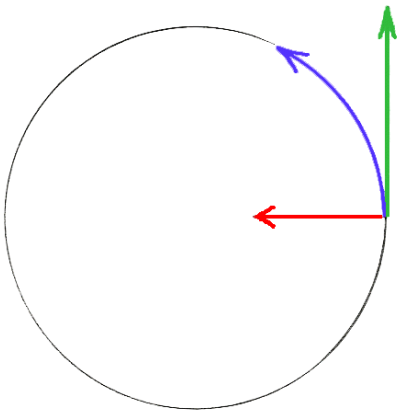
Indeed, unlike the situation observed at rest, the equilibrium is destroyed because there is now two forces involved in the system:

- one is vertical, of equal and opposite to the weight intensity, it keeps the ball in the air;

- the other is horizontal and centripetal orientation, it maintains the rotating ball.

The thread tension is equal to the resultant (in other words, to the vector sum) of these two forces.

This description is complete as well! There is no need to add anything, especially not centrifugal force. There is no need, and for good reason: the centrifugal force does not exist!



The device seen from above: the ball turns around an axis (blue arrow) because of the centripetal force (red arrow) transmitted by the thread (the axis and the thread does not appear in the drawing). If this force suddenly ceased to be, for example in the event of wire breakage, the ball comes to itself and immediately describes a straight path (green arrow).

Calculation of the centripetal force

What relationship should be used to calculate the intensity of the centripetal force? Only this one:

$$\mathbf{F = M\ V^2 / R}$$

According to the International System of Units (**SI**) and to ensure the validity of the relationship, the mass M of the ball shall be expressed in kilograms (kg symbol), its speed V in meters per second (symbol $m.s^{-1}$) and the radius R of its trajectory in meters (m symbol).

The result is expressed in newtons (symbol N), the international unit of force.

The consistency of units and checks:

$$\mathbf{F} = kg\ .\ (m.s^{-1})^2\ .\ m^{-1} = kg\ .\ m^2.s^{-2}\ .\ m^{-1} = kg\ .\ m.s^{-2} = \mathbf{N}$$

The third principle of Newton

The third Newton's principle states that any force acting on a mass causes an equal intensity but opposite reaction.

How this principle, often misunderstood, does apply in the case of the device described above? Very simple and very logical way: the ball in rotation exerts a pull on the wire, and therefore on the axis. The intensity of this traction is equal to the vector sum of the weight of the ball and the centripetal force(4).

If the ball goes on the circular path while the axis remains insensitive to this traction, it is either because the motor forms a substantially heavier mass than the ball, either because the device is firmly fixed to the Earth(5).

Moreover, we agreed that if this were not the case, the axis and engine would be overthrown by the movement of the ball.

A ‘static’ description

Now imagine the same device, this time with an observer placed on the axis and turning at the same time as him. The observer then having no longer any perception of rotation, it would require him to think in static, that is, to reason as if the ball kept turning.

Twisted reasoning? Weak hypothesis? Not at all! Humanity has reasoned thus for millennia, until the advent of Copernicus, Galileo and Newton! Indeed, the era of reasoning was to describe the movement of the Sun and the planets of the solar system with the assumption that the Earth was stationary!

The funny thing is that this way of thinking still continues today! It was decked qualifiers that few scientists really understood the meaning and scope: they say we reason in the framework of a relative standard, non-inertial and non-Galilean. In short, we simply specify static reasons, it strictly is the same!

As for the manual, do not look elsewhere! Our website is almost the only one to carefully distinguish descriptions, and taking great care never to mix!

This reasoning is called 'static' as opposed to reasoning 'dynamic' discussed above. What are the limits of this reasoning?

The ball rotational movement is now frozen, as if watching from a photograph. How then to explain the angle that the wire forms with the vertical? This is where the centrifugal force appears. Centrifugal the misnamed!

Indeed, to keep the ball in balance and explain the angle formed by the wire with vertical, imagine a fictitious force acting horizontally on the ball of the center of gravity, but facing away from the axis! That is the centrifugal force! The misnamed because there is no more circular path and center, the ball rotary motion having disappeared in the eyes of the

beholder!

Let us add here, the third principle of Newton is strictly inapplicable since there is no interaction, the centrifugal force being an imaginary force.

Calculation of the centrifugal force

What relationship should be used to calculate the intensity of centrifugal force? This one, and this is the only one:

$$\mathbf{F' = -M\,g}\ \text{tangent}\ \alpha$$

The sign [–] to specify the spatial orientation of the force. According to the International Units System (SI) and to ensure the validity of the relationship, the mass M of the ball shall be expressed in kilograms (kg symbol), the gravitational acceleration **g** in meters per second squared (symbol $m.s^{-2}$) and the angle α of the wire with respect to the vertical, in either degrees or radians (trigonometric values have no dimension).

The result is expressed in Newtons (N symbol) which is the international unit of force.

The consistency of units and checks:

$$\mathbf{F'} = kg\ .\ m.s^{-2} = \mathbf{N}$$

Equality = danger!

A numerical application of these two relations give a surprising result: all other conditions being equal, we find that the centripetal force in dynamic and static centrifugal force have exactly the same intensity!

However, nothing should be concluded again because these two forces do not belong to the same description! The worst mistake is to confuse or mix them:

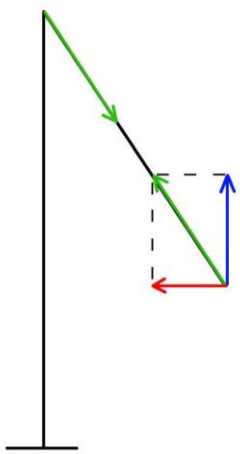
- one of these two forces is exercised by direct contact of the yarn on a ball in motion, the other is exercised miraculously on the center of gravity of a ball motionless;

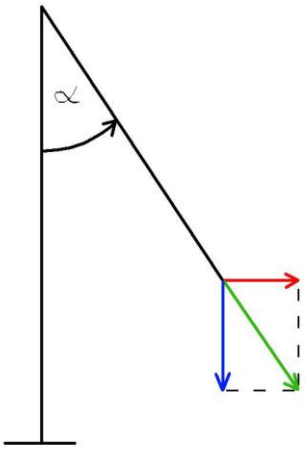
- one of these two forces is the result of an interaction, the axis of the thread and the thread on the ball, the other not;

- one of these two forces is the centripetal direction, the other centrifugal direction. Moreover, to avoid confusion, a good precaution is to dress up the centrifugal force of a negative sign to specify the direction, contrary to the logic of the movement.

Two drawings to understand ...

The previous two descriptions are not to be confused or mixed, it is imperative to distinguish them by two separate drawings, like these:





First drawing: the dynamic description of the rotation of a ball around an axis, in a horizontal view.

- the blue arrow represents the lift force, the force that keeps the ball in vertical balance;

- the red arrow represents the centripetal force, the force that keeps the ball on a circular path;

- the two green arrows: one represents the resultant of the two aforementioned forces, it exerts on the ball through the wire; the other is the reaction to the resultant, it is exerted on the rotation axis through the wire.

Second drawing: the static description of the phenomenon, the axis does not rotate, the ball is stationary in space, as if by magic, the wire forms an angle to the vertical.

- the blue arrow represents the weight of the ball;

- the red arrow represents the centrifugal force;

- the green arrow represents the resultant of these two forces.

Conclusion

This is the conclusion: beware of numerous values!

Beware of calculations with identical results, they do not allow for much interchangeable concepts and reasoning!

So follow these tips: always distinguish the nature, the point of application and direction of the different studied forces and associated reactions; never mix descriptions; never associate a real force and an imaginary force!

Also, do not hesitate to question the certainties, demonstrations or drawings of your professors, as friendly, qualified and competent as they are! Research has in fact shown that the best of them could unintentionally mislead generations of pupils and students (see the folder ADILCA '*Cessac & Treherne*').

(1) *'Pseudo-physicists': so we called, derisively, the physicists who persist in considering only the fictitious forces or pseudo-forces, ignoring the others.*

(2) *During the acceleration phase, the engine work provides a kinetic energy corresponding to the speed acquired by the ball (neglecting the mass of wire and air resistance), to which must be added the gravitational energy corresponding to the height difference between the position of the ball at rest and its position after the stabilized speed.*

(3) *This force is called a centripetal here for simplicity, but it is actually a guiding force: indeed, the wire never approaches the ball from the axis, it simply deviates it from a straight line to give a circular path (see ADILCA folder 'centripetal force').*

(4) *Here, we neglect the mass of wire; However, in the case of a fairground carousel, it would obviously take into account the mass of the support arm.*

(5) *This means that, in the final analysis, the real forces are all the result of an interaction with the Earth.*

ASSOCIATION ADILCA

www.adilca.com

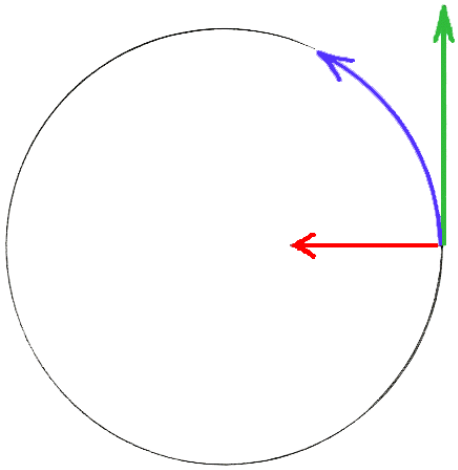
*** * ***

3. THE EARTH THAT TURNS AROUND THE SUN

The laws of physics are those of the Universe, so these are universal laws: they apply equally to the centrifuge to the ball that rotates around an axis, to the path of a car, to the balance of the solar system or to any other phenomenon, this is has been discovered by the genius of Isaac Newton.

These laws apply to the study of the movement of the Earth which orbits the Sun at a speed of 30 kilometers per second along a circular path radius of 150 million kilometers.

How to explain this trajectory? It is due to the gravitational force created by the mass of the sun. This mysterious force (also called centripetal force) acts at a distance, it is of the same nature as that which, on Earth, knocking objects on the ground.



Schematic representation of the motion of the Earth.

Earth describes a circular path (blue arrow) because of the gravitational force (red arrow) which attracts towards the sun. If this force did not exist, the Earth would take a straight path (green arrow).

Change the laws of the Universe ...

Imagine that the laws of the universe are completely changed. What would happen if the Earth had a zero speed or suddenly ceased to obey the attraction of the Sun?

- without a cruise but subject to the force of gravity, the Earth immediately would take the direction of the Sun to come and melt it.

- insensitive to gravitation but retaining his speed, Earth immediately would adopt a straight path and moves away from the Sun.

Insist on this point: if the Earth was moving away from the Sun, it would be a gravitational force default and not because of any centrifugal force.

The third principle of the third Newton

Newton's principle states that any force acting on a mass causes an equal intensity but opposite reaction.

Does this principle apply in the case of the solar system? Yes of course!

The Sun attracts the Earth, so Earth also draws the Sun, with unabated strength but opposite! This force acts at the center of the Sun, it is oriented towards to the center of the Earth.

Why only Earth inflects its trajectory, the sun remaining perfectly still? It is a question of power between two bodies of unequal masses: the Sun is 333,333 times more mass than the Earth(*).

Conclusion

The concept of centrifugal force is not longer necessary in this description than in any other!

(*) *Mass of the Sun (S): 2 x 10^{30} kg; mass of the Earth (T): 6 x 10^{24} kg; ratio S / T: 0.33 x 10^{6}.*

ASSOCIATION ADILCA

www.adilca.com

*** * ***