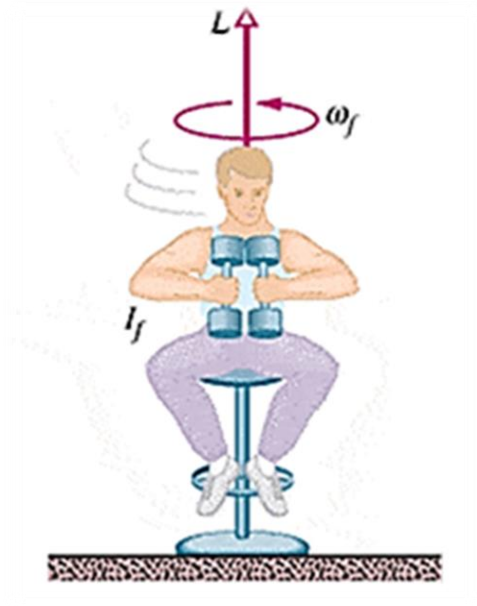
Στερεά σώματα σε περιστροφική κίνηση

Solid bodies in rotating motion



1ο πείραμα

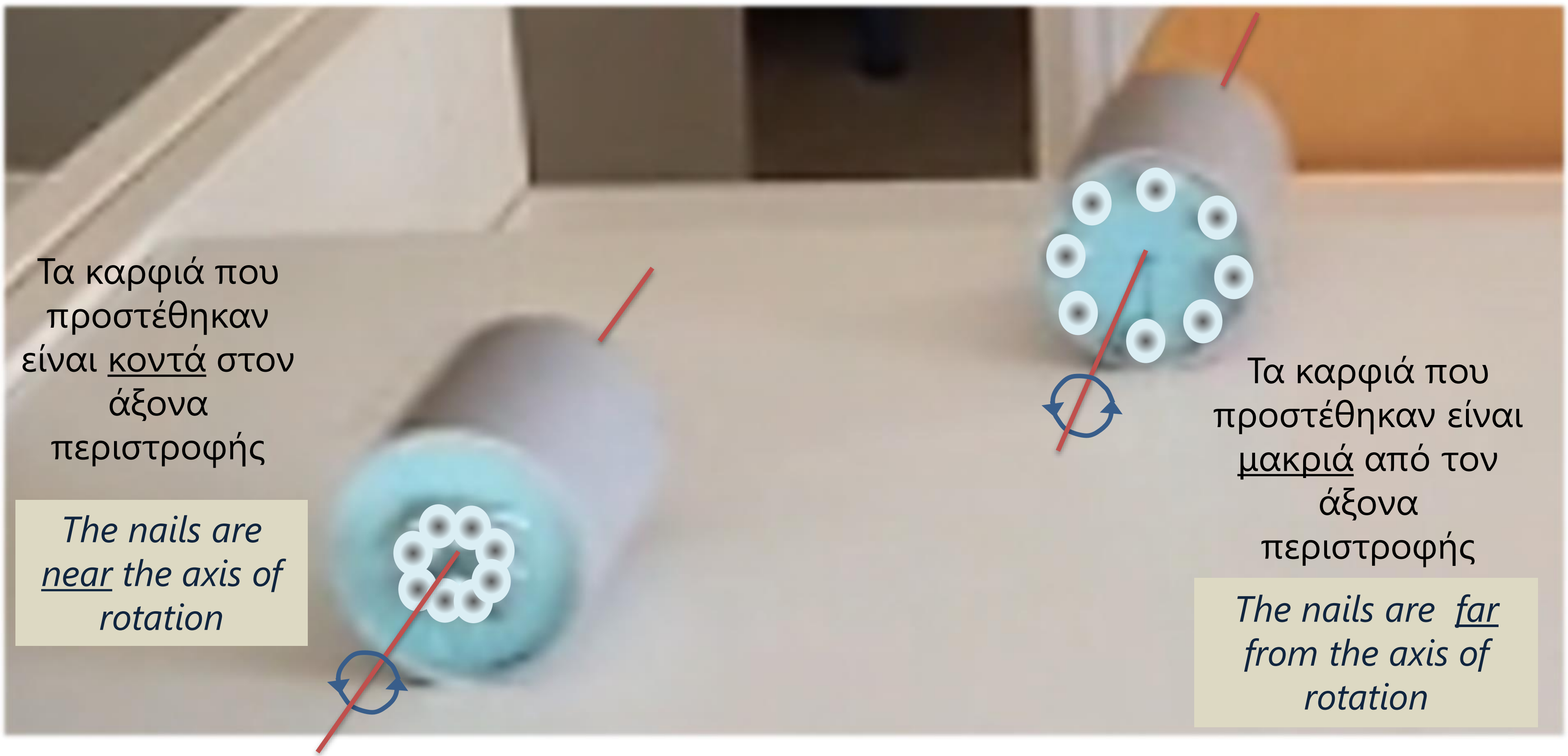
Τα υλικά για την επίδειξή μας

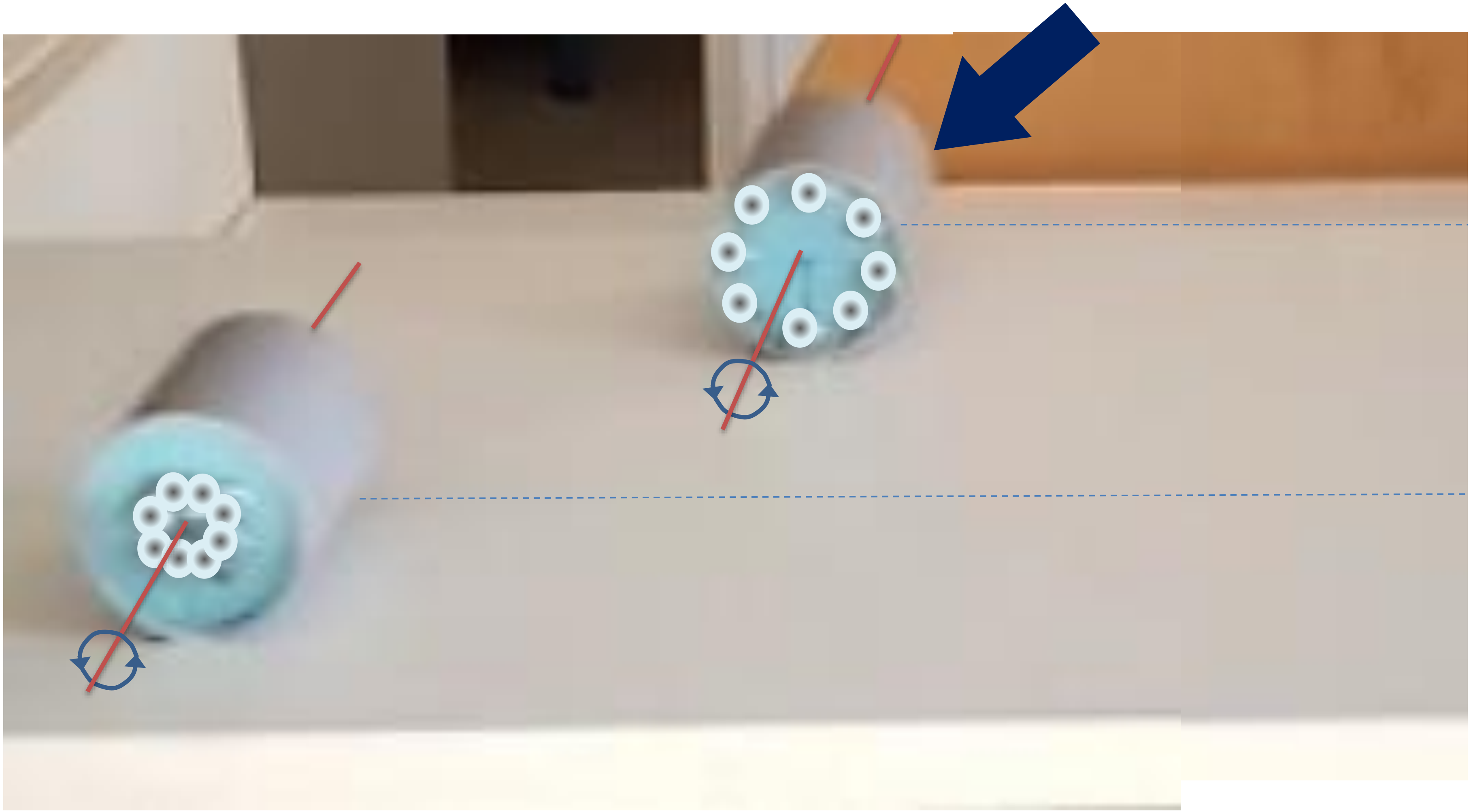
The materials for our demonstration

1. *Ένα θρανίο με κλίση (κατηφόρα)*
   A sloping desk (downhill)

2. *Δύο πλαστικοί κύλινδροι με γέμιση φελιζόλ και βίδες*
   Two plastic cylinders with styrofoam filling


Ένα στιγμιότυπο από το πείραμα
Snapshot from the experiment


Τα καρφιά που προστέθηκαν είναι κοντά στον άξονα περιστροφής
The nails are near the axis of rotation
Τα καρφιά που προστέθηκαν είναι μακριά από τον άξονα περιστροφής
The nails are far from the axis of rotation



Όσο <u>πιο μακριά</u> από τον άξονα περιστροφής είναι η μάζα του σώματος, τόσο <u>πιο πολύ δυσκολεύεται</u> το σώμα, στην κυκλική κίνηση

The farther the mass of the body is from the axis of rotation the more difficult the circular motion is

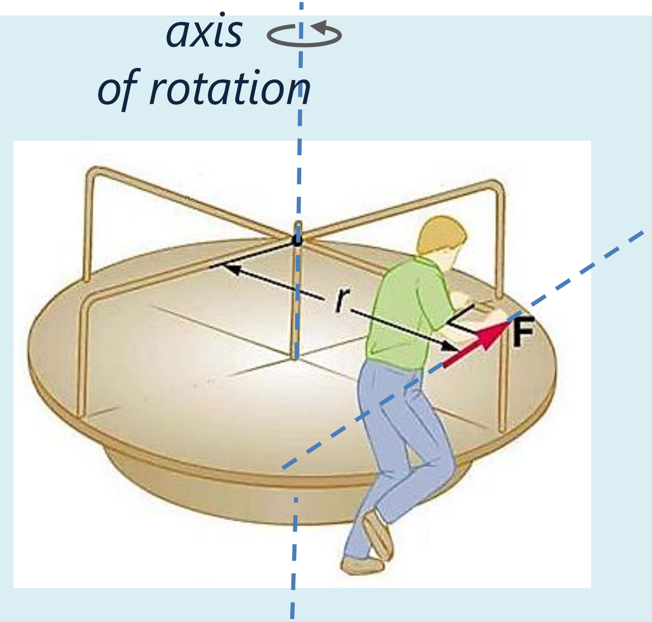
2ο πείραμα

Όλοι έχουμε παίξει αυτό το παιχνίδι !

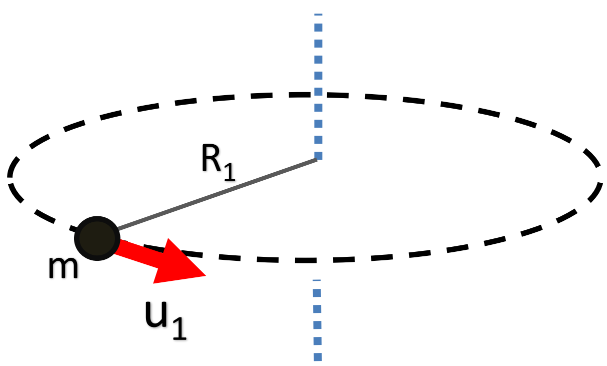
Everybody has played this game !

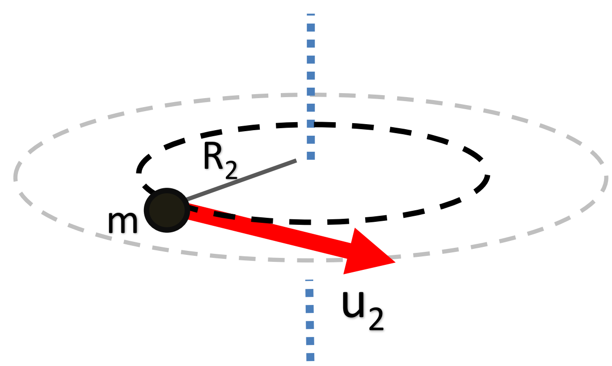
- The **force** (F) that does not pass through the axis of rotation is the **cause** for the body to start rotating.

- When the force (F) stops acting, the rotating body **continues to rotate** (**Inertia**).



The rotation will be slow or fast **depending on the distance of the mass** from the axis of rotation.

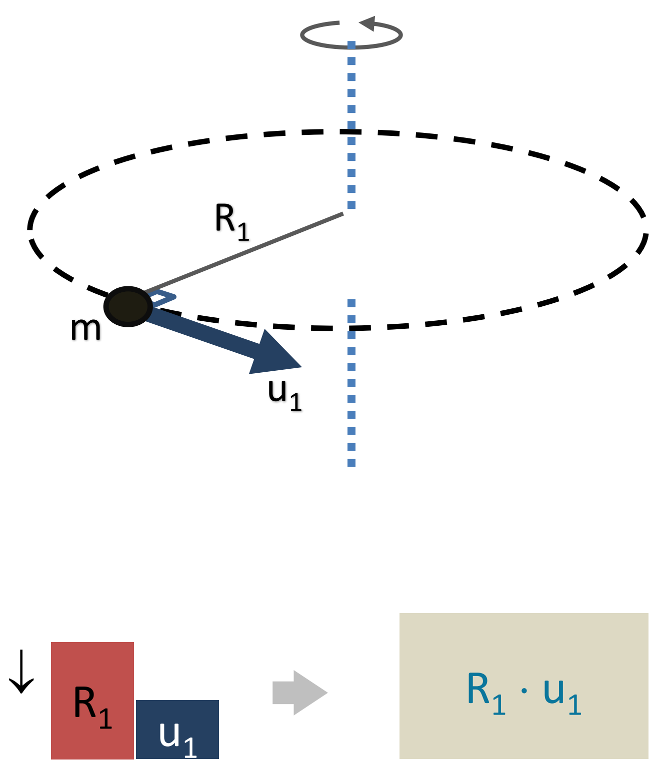


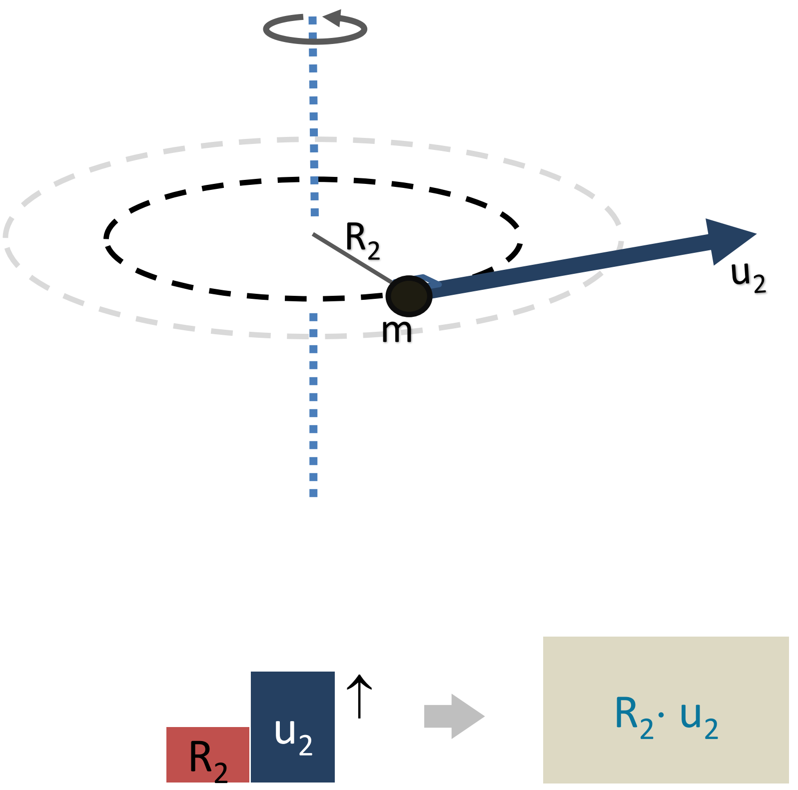


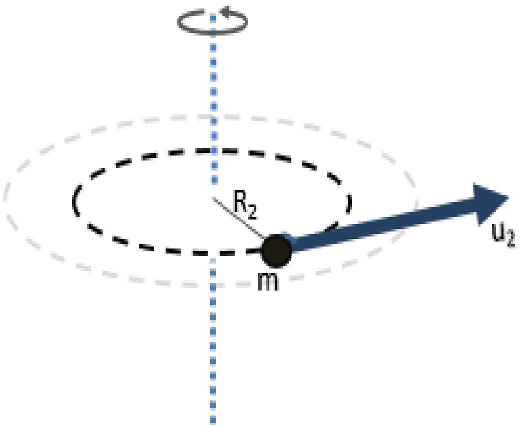
It appears that **after the action of the force (F)**, the rotating body is in a state where:

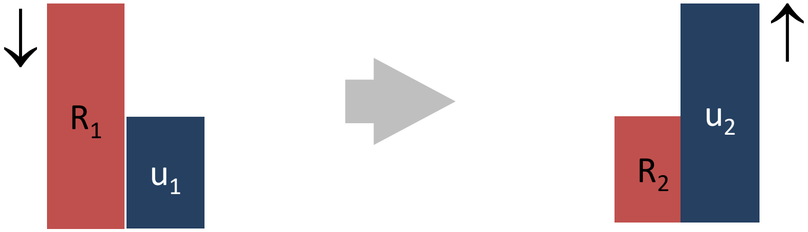
the **distance (R)** from the axis and the **rotational speed (u)** are quantities inversely proportional.

That is by reducing (↓) the radius (R) we achieve a higher (↑) rotation speed (u)









Ποιος **φυσικός νόμος** «κρύβεται» πίσω από αυτό το φαινόμενο ;
Γιατί συμβαίνει με τον τρόπο αυτό ;

What **natural law** is "hidden" behind this phenomenon?

We know that quantities that are inversely proportional have a constant product. Thus, when a body rotates without the action of external forces, then the quantities **u** and **R** have a constant multiplication ($\mathbf{u} \cdot \mathbf{R}$ = const.)

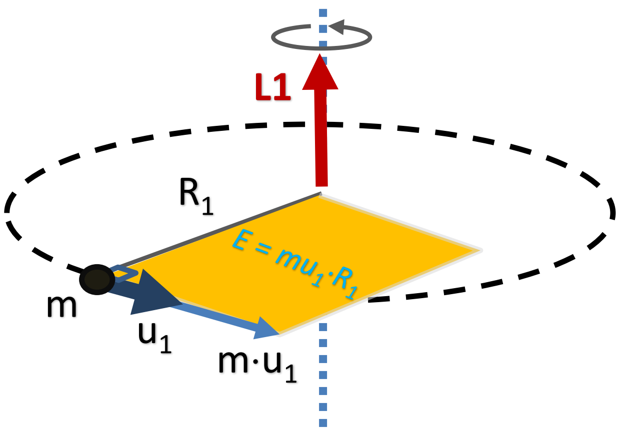
So : $\mathbf{u_1 \cdot R_1 = u_2 \cdot R_2}$

For Physics the product ($u \cdot R$) multiplied by mass (m) leads to a new quantity, which concerns the rotation of the body and is called

Angular momentum ($\mathbf{L = m \cdot u \cdot R}$)

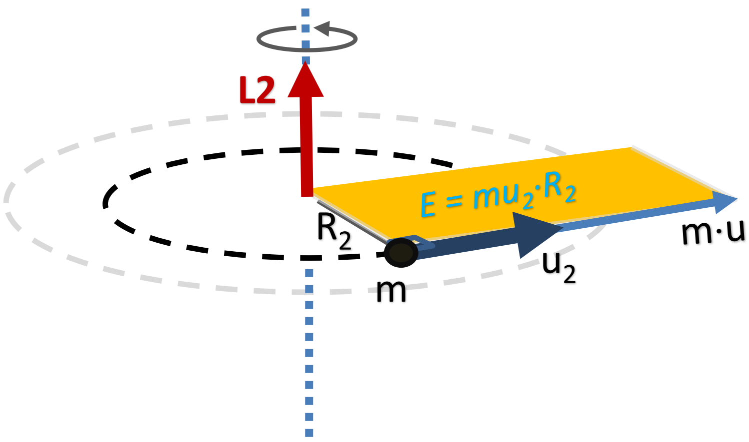
And the rotation experiment shows that:

$$u_1 \cdot R_1 = u_2 \cdot R_2 \rightarrow m \cdot u_1 \cdot R_1 = m \cdot u_2 \cdot R_2 \rightarrow \mathbf{L_1 = L_2}$$



$R_1 \times (m \cdot u_1) = \mathbf{L}$

Angular momentum

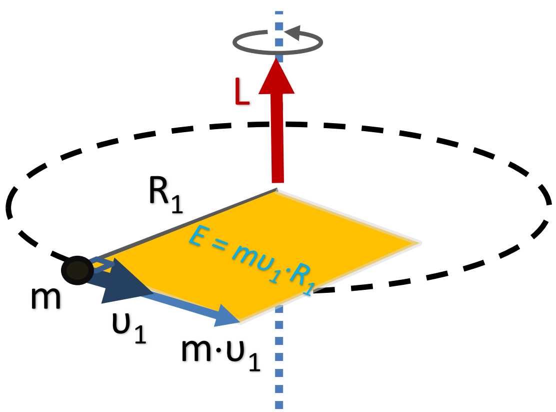


$R_2 \times (m \cdot u_2) = \mathbf{L}$

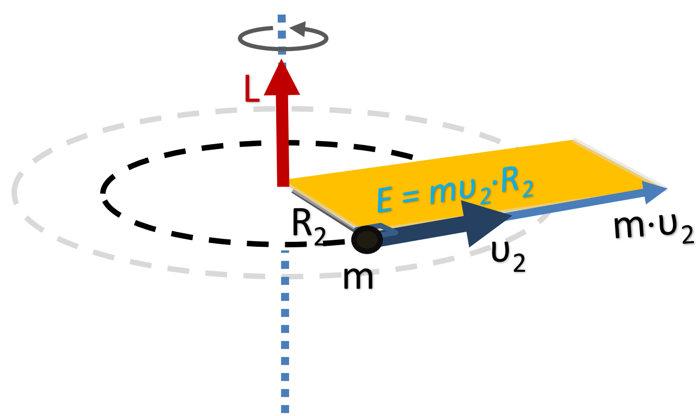
Angular momentum

Finally, the natural law that is "hidden" behind the phenomena of rotation is **the law of conservation of angular momentum**.

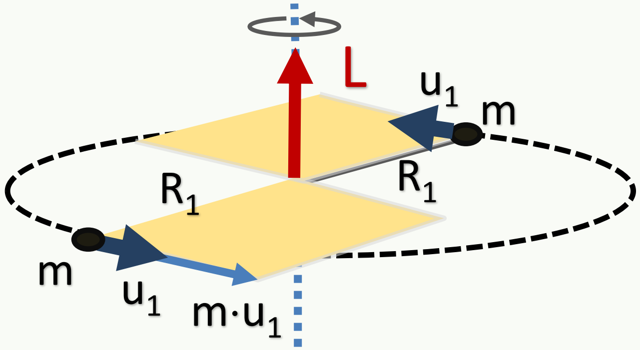
«If a body of mass (m),which is rotating with speed (u) in radius (R) from the axis of rotation <u>without the action of external force,</u> changes the radius of rotation, then its angular momentum (L = muR) will remain the same by changing the speed of circular motion»



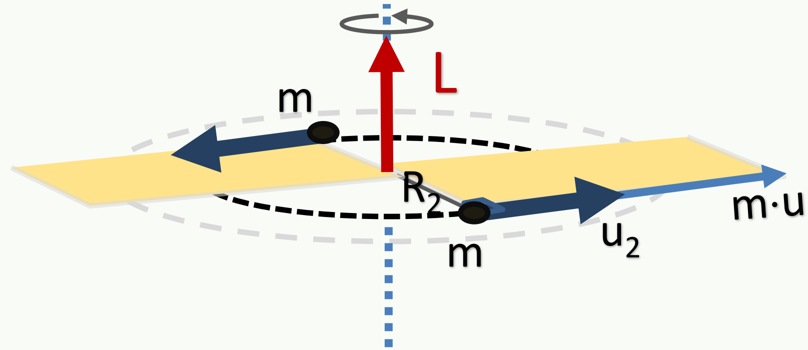
R_1 x $(m_1 \cdot u_1) = L$



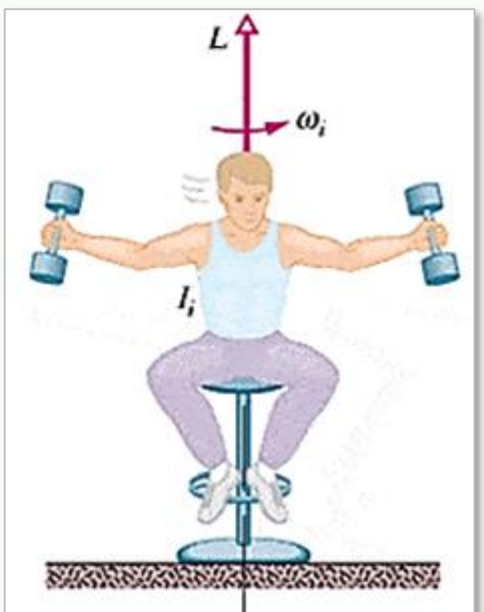
R_2 x $(m \cdot u_2) = L$



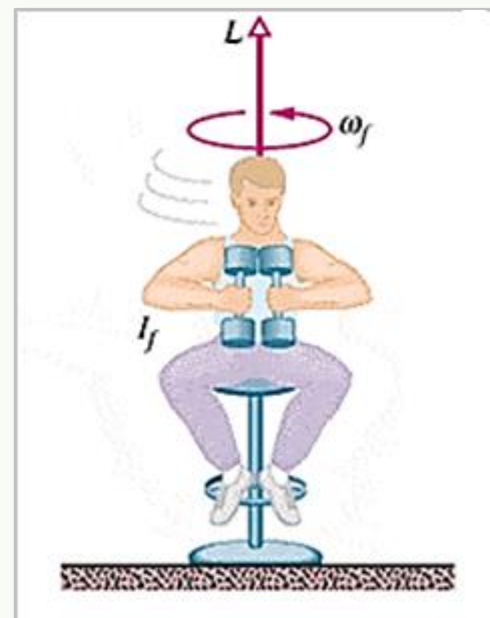
$$L_1' + L_2' = L$$



$$L_1 + L_2 = L$$



Rotation of the body at long distances from the axis and slow speed

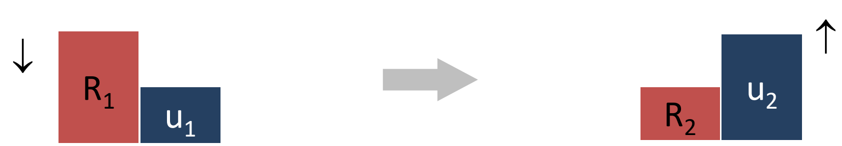


Rotation at short distances from the axis and fast speed

The law of conservation of angular momentum

Rotation of the body **at long distances** from the axis and **slow speed**

Rotation at **short distances** from the axis and **fast speed**



The **angular momentum (L)** did not change

3ο πείραμα

Bicycles in motion

Bicycle in motion

Balancing is easy

Immovable bicycle

Balancing is impossible

How do you explain it ?

Bicycle in motion

The rotating wheels **have a angular momentum (L)** that wants to **be maintained** and maintains the circular motion

Immovable bicycle

There are no rotating bodies... and **there is no angular momentum (L)** to maintain!

The spinning wheels have an **angular momentum (L)** which **maintains** their circular motion

That's why it is easy to ride a bike

Στροφορμή / Angular momentum (L)

- Όταν η ρόδα <u>δεν περιστρέφεται</u> ,η ισορροπία της είναι σε θέση οριζόντια.

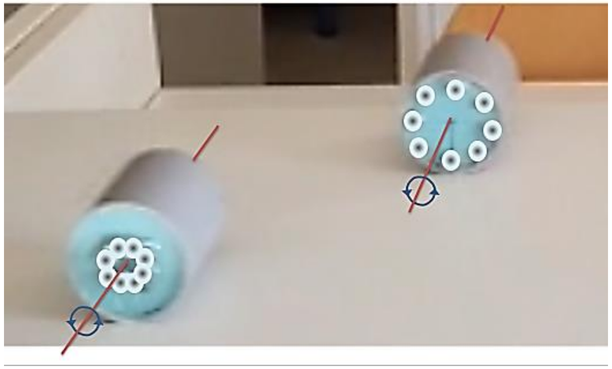
- Όταν η ρόδα <u>περιστρέφεται</u> ,η στροφορμή της (L) την κρατά περιστρεφόμενη και κατακόρυφη.

- When the wheel does <u>not rotate</u> its balance is in a horizontal position.

- When the wheel <u>rotates</u> its angular momentum (L) keeps it upright and rotating.

Συμπεράσματα / Conclusions

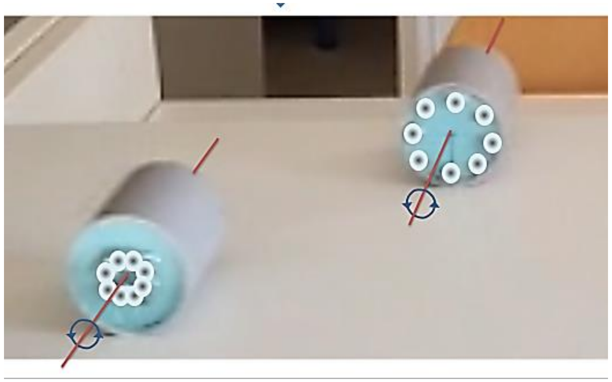
1. Στα περιστρεφόμενα σώματα είναι σημαντική η **απόσταση της μάζας από τον άξονα περιστροφής**. Όσο πιο μακριά είναι η μάζα από τον άξονα περιστροφής τόσο πιο πολύ δυσκολεύεται να τεθεί σε κυκλική κίνηση



2. Στα περιστρεφόμενα σώματα υπάρχει ένα **φυσικό μέγεθος που για να αλλάξει** απαιτείται εξωτερική παρέμβαση. Το μέγεθος αυτό λέγεται στροφορμή (L).
Αν δεν υπάρξει εξωτερική παρέμβαση η στροφορμή διατηρεί την κυκλική κίνηση.

Συμπεράσματα / Conclusions

1. In rotating bodies, the distance of the mass from the axis of rotation is important. The farther the mass is from the axis of rotation the more difficult it is to set in a circular motion



2. In rotating bodies there is a physical quantity that requires external intervention to change. If there is no external intervention, the circular motion is maintained.

General Lyceum of Mouzaki
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Thanks for watching