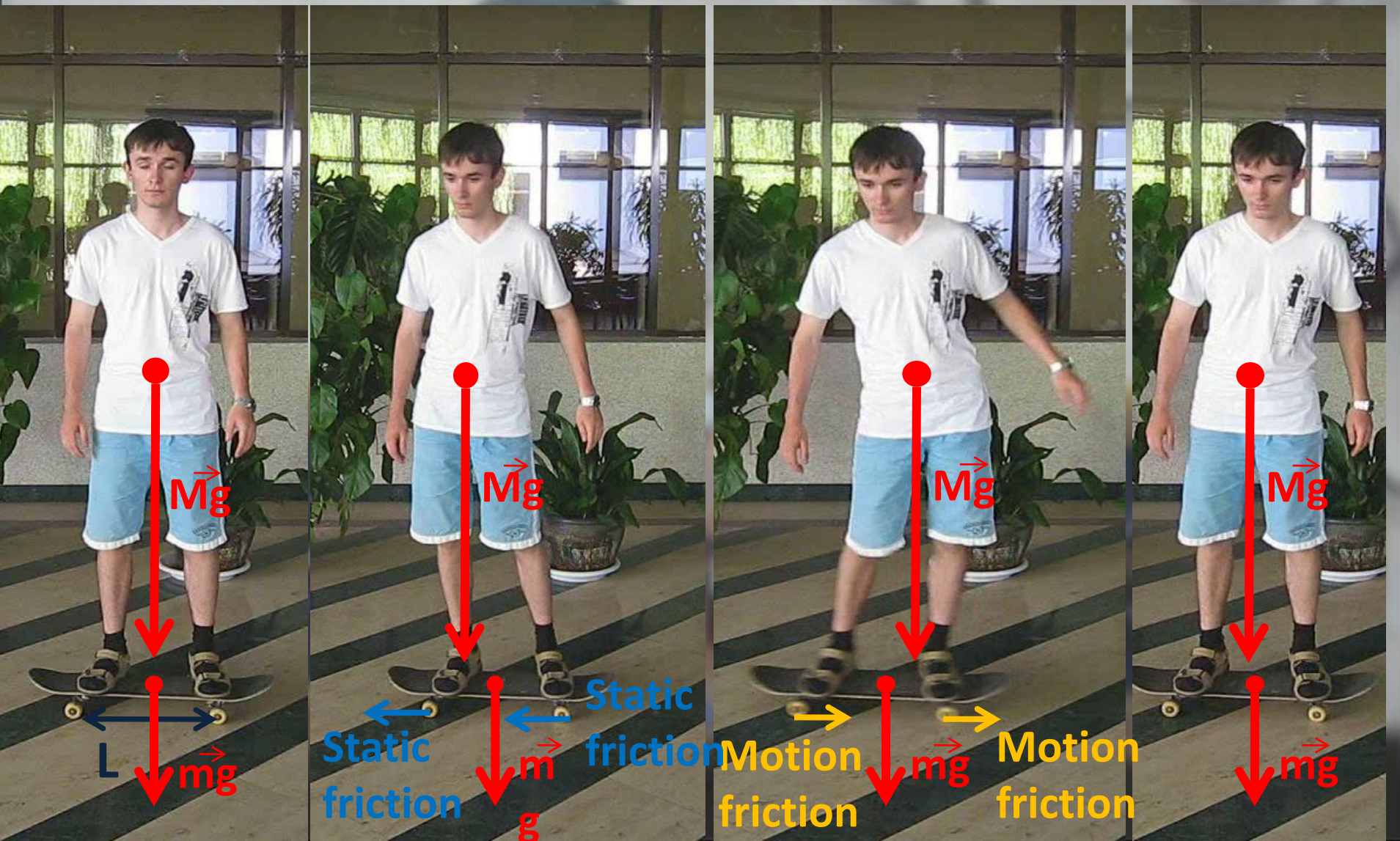

Skateboarder

7. Skateboarder

A skateboarder on a horizontal surface can accelerate from rest just by moving the body, without touching external support. Investigate the parameters that affect the motion of a skateboard propelled by this method.

The most simple way to make skate moving

Forces acting the skate



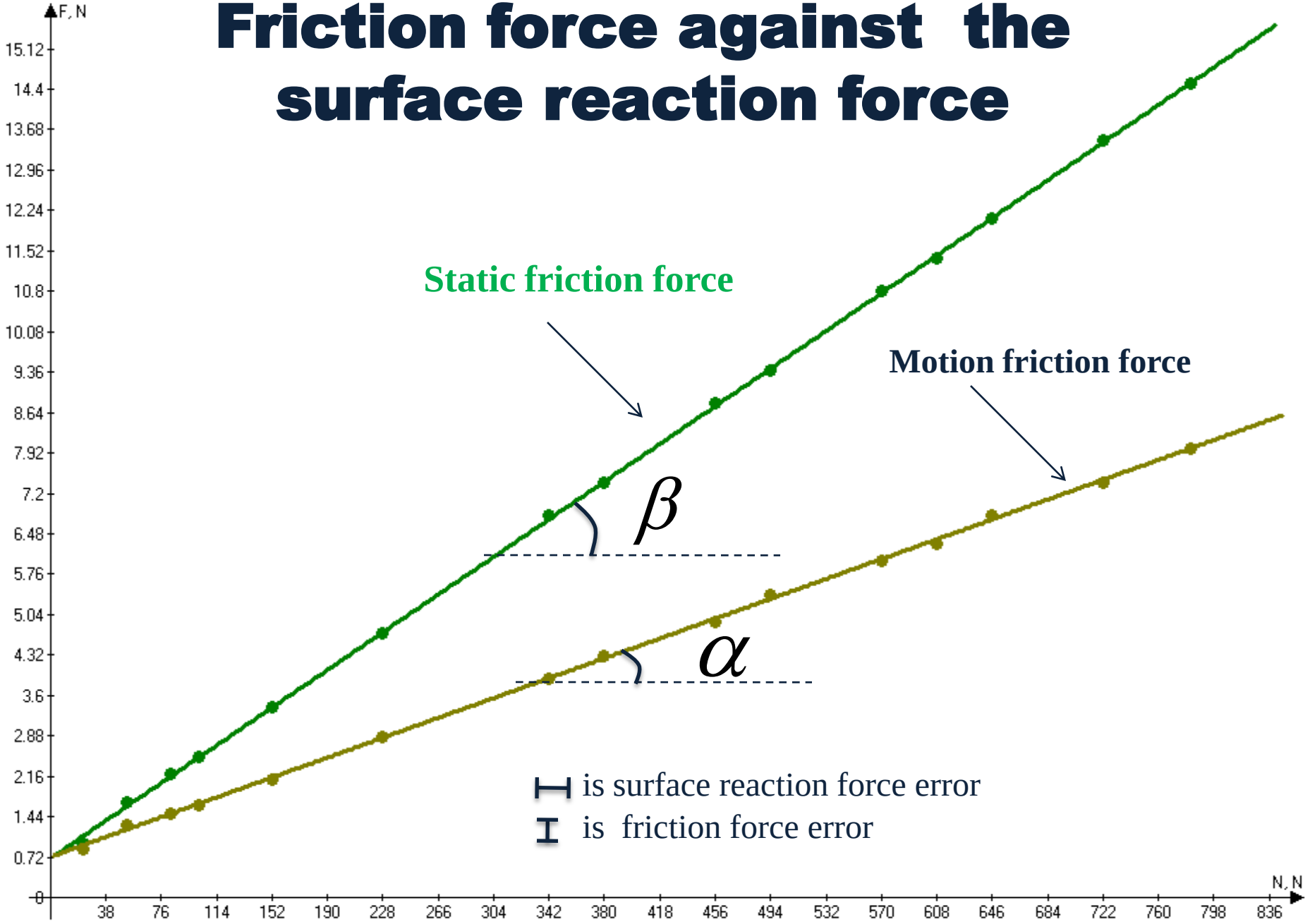
The most simple way to make skate moving

Frictions forcers

$$\vec{F}_{static\ friction} = \mu \vec{N} \quad (1)$$

$$\vec{F}_{motion\ friction} = \frac{k}{R} \vec{N} \quad (2)$$

Friction force against the surface reaction force



Calculation of friction coefficients

$$\frac{k}{R} = \tan\alpha \qquad \mu = \tan\beta$$

$$\frac{k}{R} \approx 0.010 \qquad \mu \approx 0.018$$

k and μ characterize the wheels and floor substances

Mathematical model

$$\begin{cases} a = \dfrac{MA - (M+m)g\dfrac{K}{R}}{m} \\ \dfrac{at^2}{2} = L - \dfrac{At^2}{2} \\ x = \dfrac{at^2}{2} \end{cases} \Rightarrow \begin{cases} t = \sqrt{\dfrac{2mL}{MA - Mg\dfrac{K}{R} - mg\dfrac{K}{R} + mA}} \\ x = \dfrac{\left(M(A - g\dfrac{K}{R}) - mg\dfrac{K}{R}\right)}{M(A - g\dfrac{K}{R}) - m(\dfrac{K}{R} + A)} \end{cases}$$

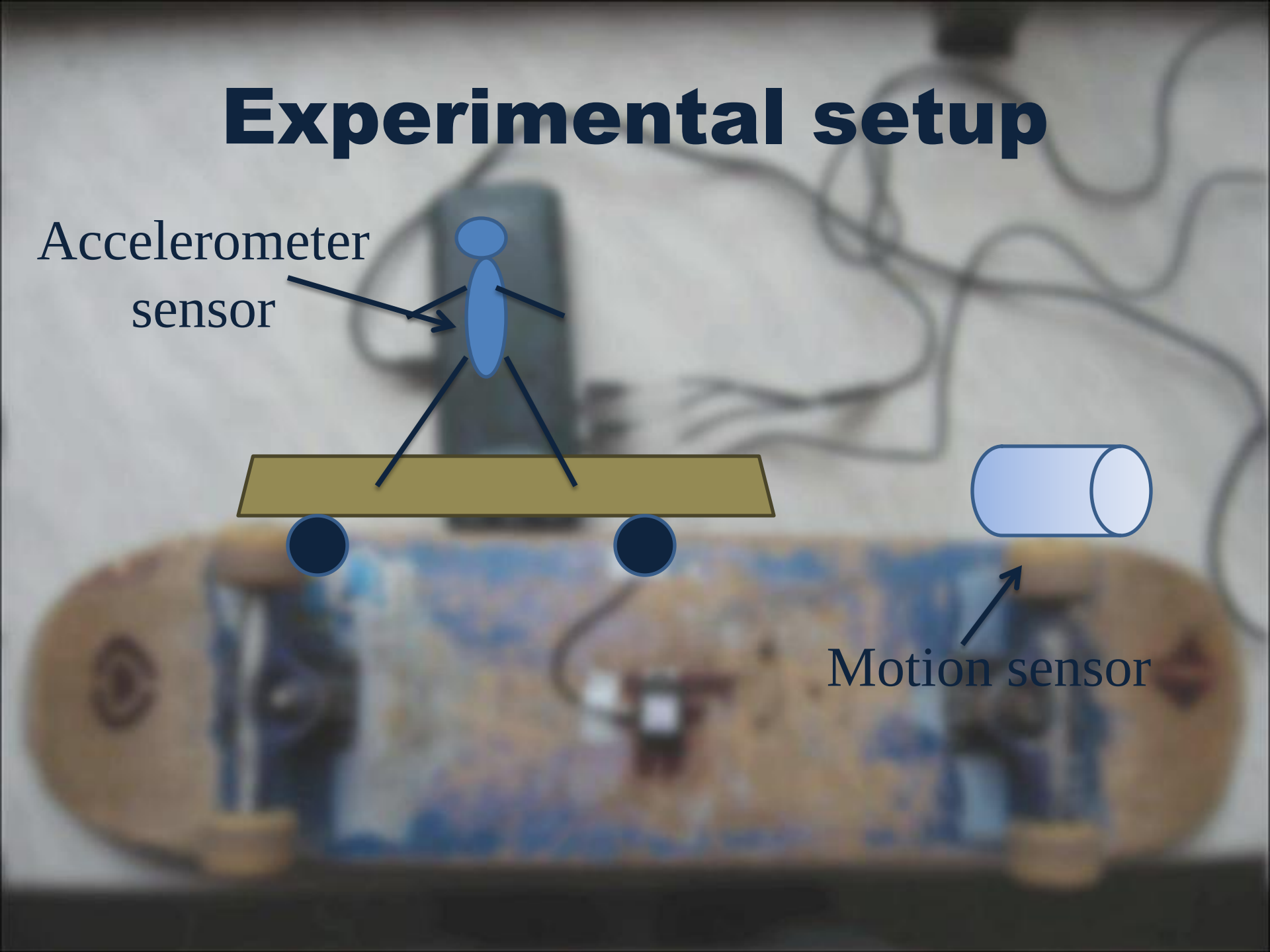
t is time of acceleration
L is the distance between wheels
A is the center mass acceleration

x is the length of acceleration
a is the skate acceleration
R is wheel diameter

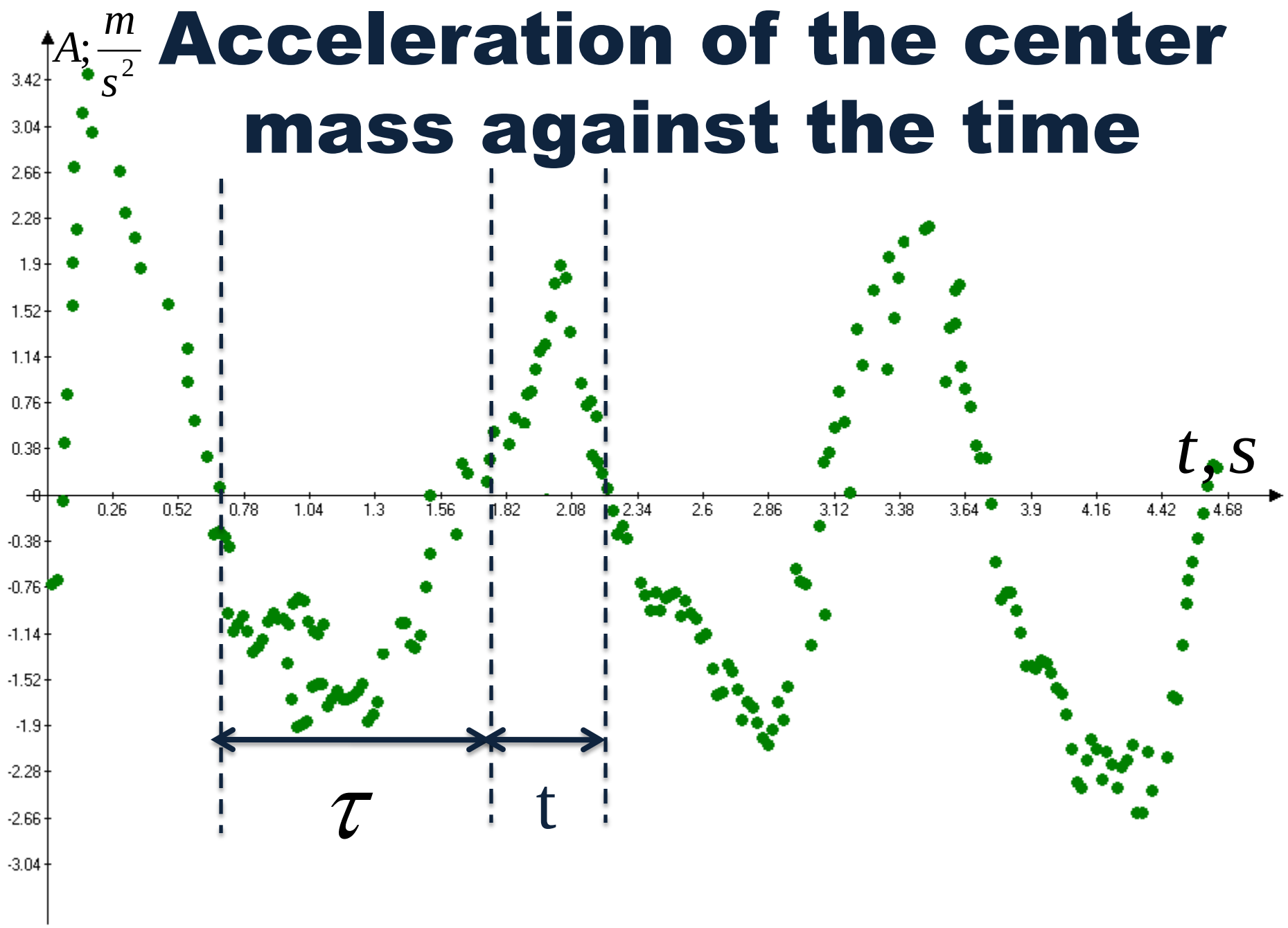
$$\begin{cases} \dfrac{A\tau^2}{2} = L \\ \mu g(M+m) = MA \end{cases} \Rightarrow \tau = \sqrt{\dfrac{2ML}{\mu g(M+m)}}$$

Where τ is the time of retuning of skateboarder center of mass

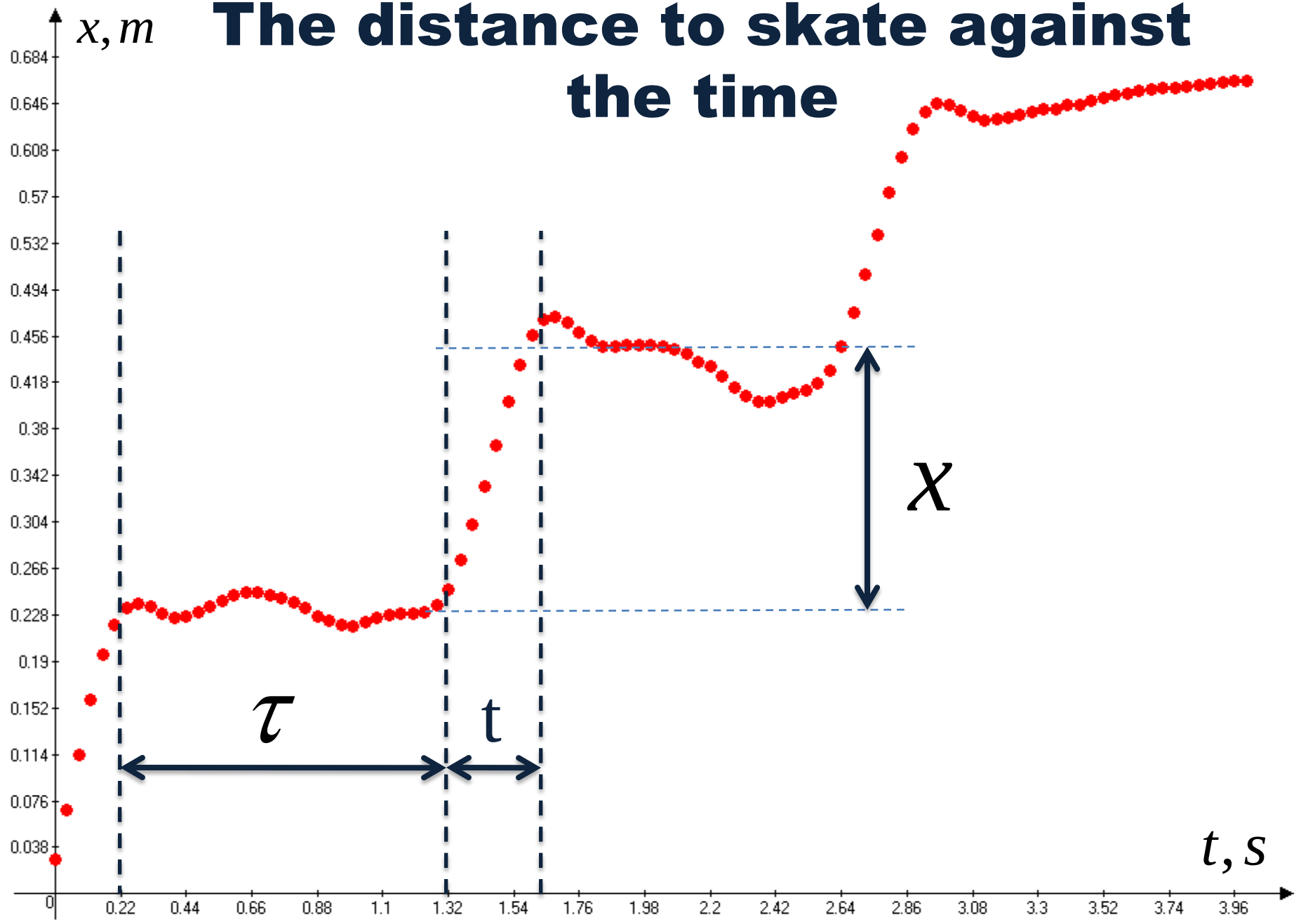
Experimental setup



Acceleration of the center mass against the time



The distance to skate against the time



Comparing the theory with the experiment

From experiment:

$\tau = 1.1s$

$t = 0.33s$

$x = 0.225m$

From theory:

$\tau = 1.0s$

$t = 0.40s$

$x = 0.23m$

Average velocity

$$<v>=\frac{x}{t+\tau}$$

$$<v>=0.16 m/s$$

Skate parameters

- ✓ Mass of a skate
- ✓ Radius of wheels
- ✓ Static friction
- ✓ Motion friction
- ✓ The length between the wheels
- ✓ The material from which the wheels and the floor are made

Skateboarder parameters

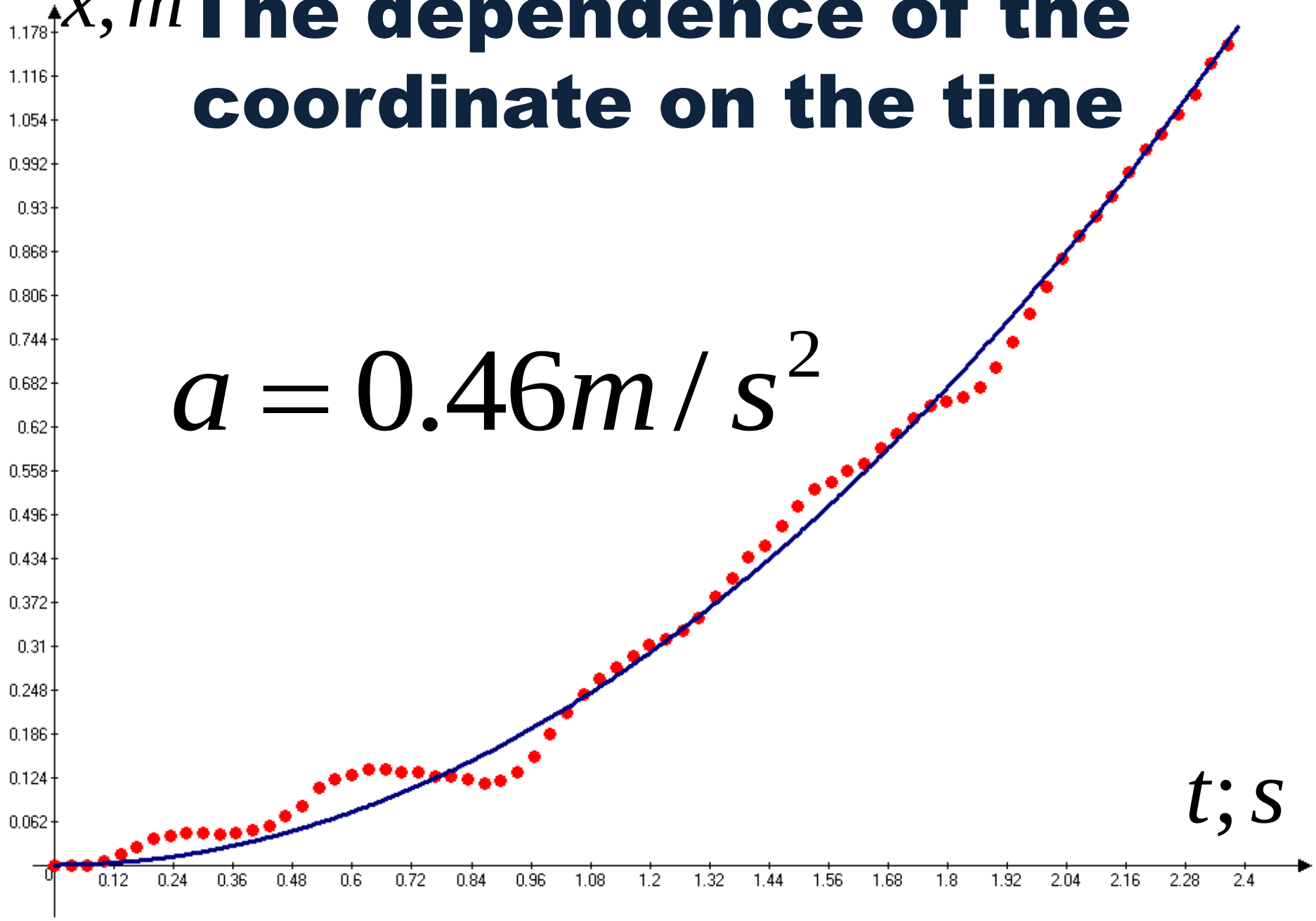
- ✓ Mass of skateboarder
- ✓ The abilities of skateboarder(acceleration of center mass)
- ✓ Experience

Advanced way to accelerate “tick-tack”

Slowed “tick-tack”

Looking down on “tick tack”

The dependence of the coordinate on the time



$$a = 0.46 m/s^2$$

Conclusions

- We have found the way to accelerate.
- We have build the mathematical model of the event
- We have measure a lot of parameters
- We have rather great experimental research
- Our theory agrees with the experiments


Thank you for your attention