



evropský
sociální
fond v ČR



EVROPSKÁ UNIE

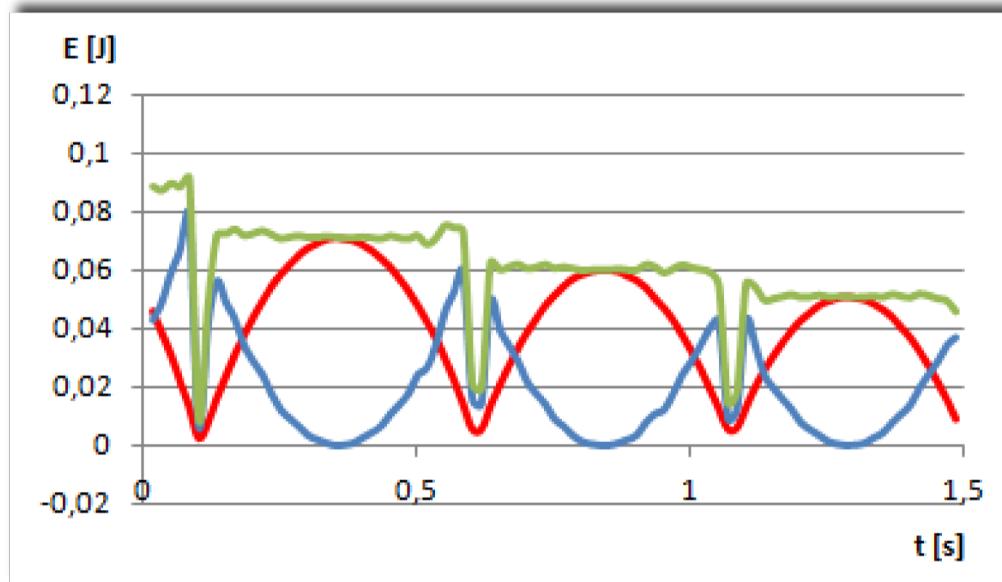


MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Physics and Sport



Leopold Mathelitsch
Institute of Physics
University of Graz

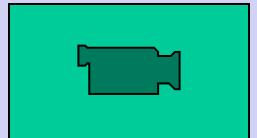
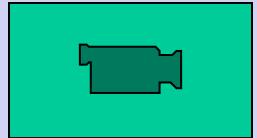
Olomouc
November 22, 2013

Moduly jako prostředek inovace
v integraci výuky moderní fyziky a chemie

Visualization

Billiard

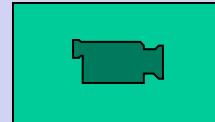
Follow Shot



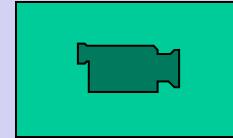
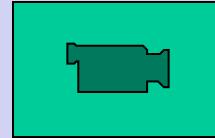
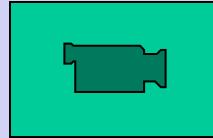
Video Analysis

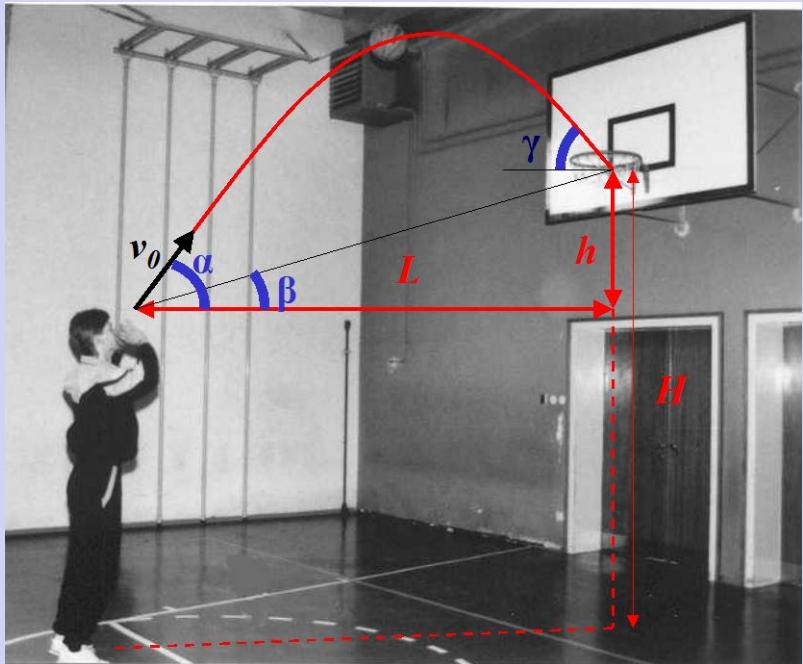
Basketball

Video

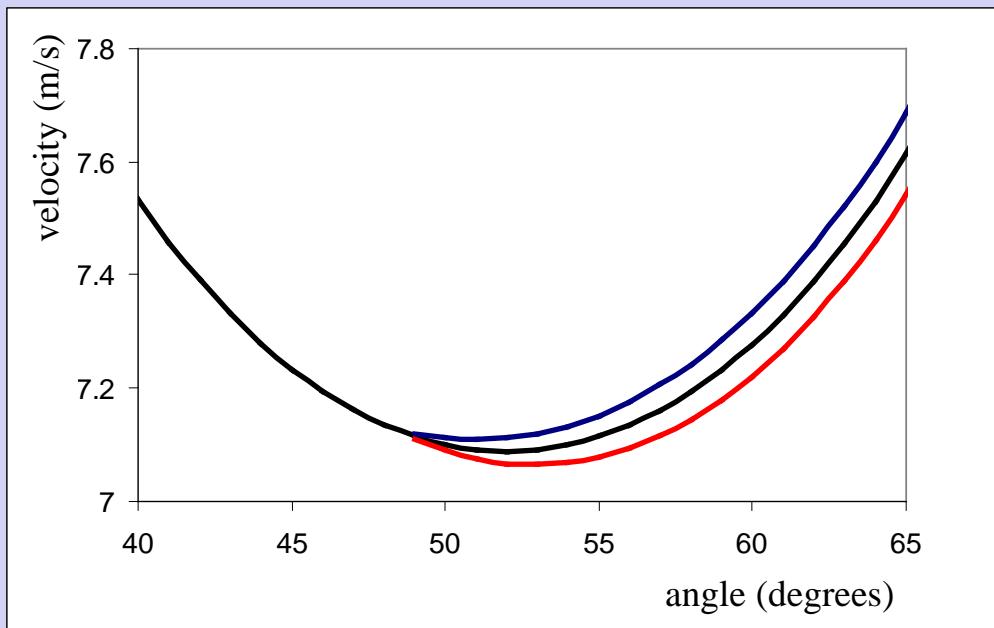


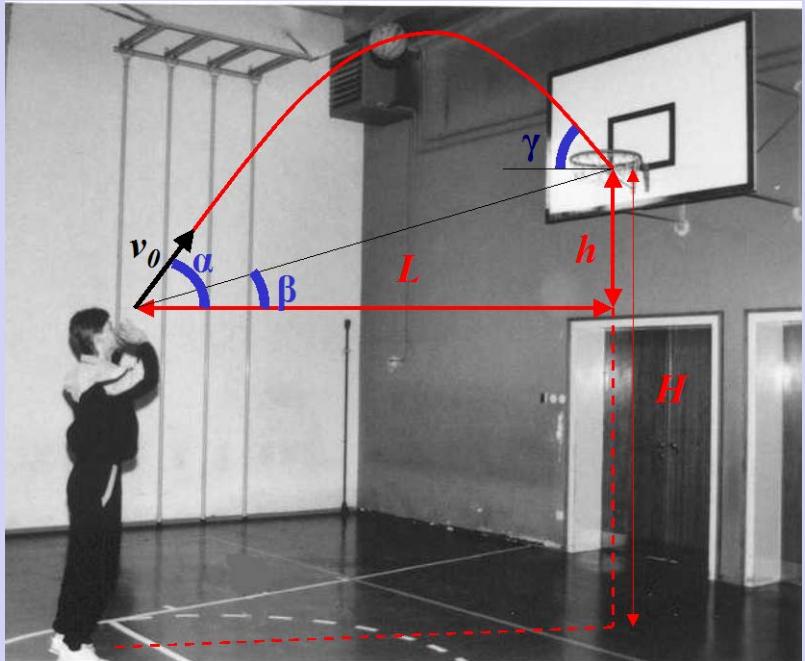
Analysis



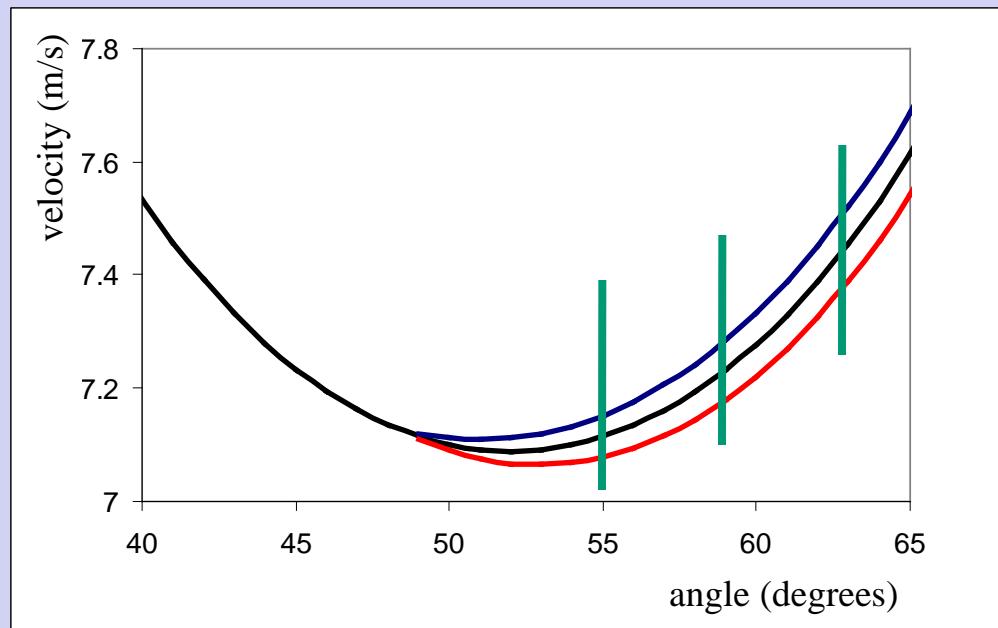


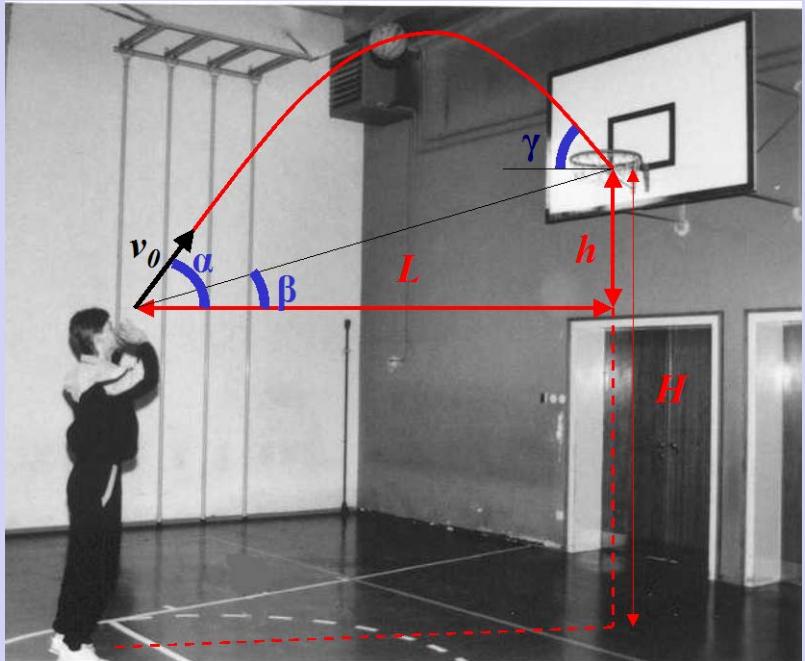
Basketball more success



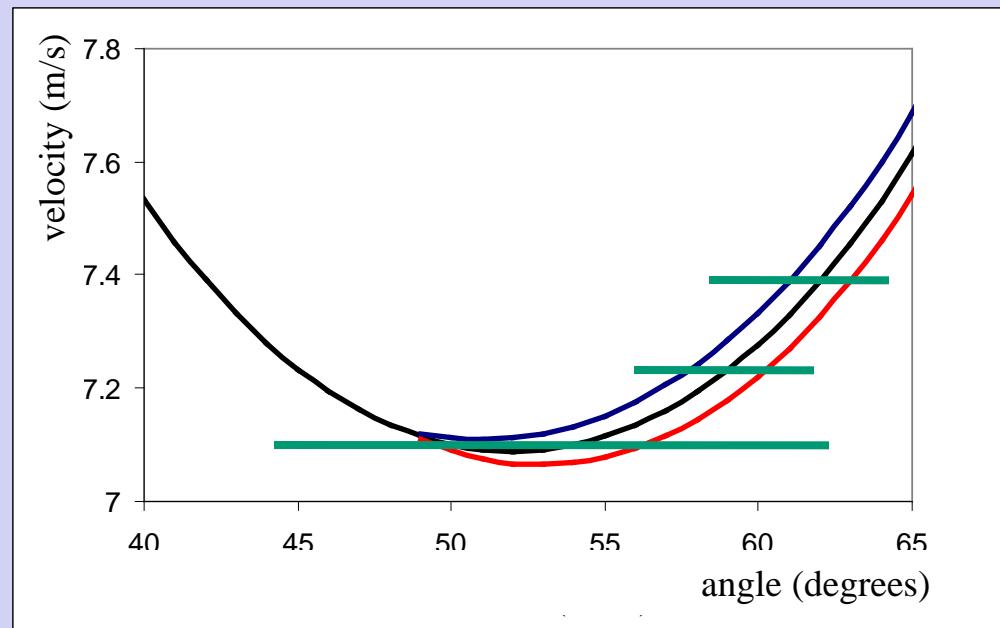


Imprecision in velocity

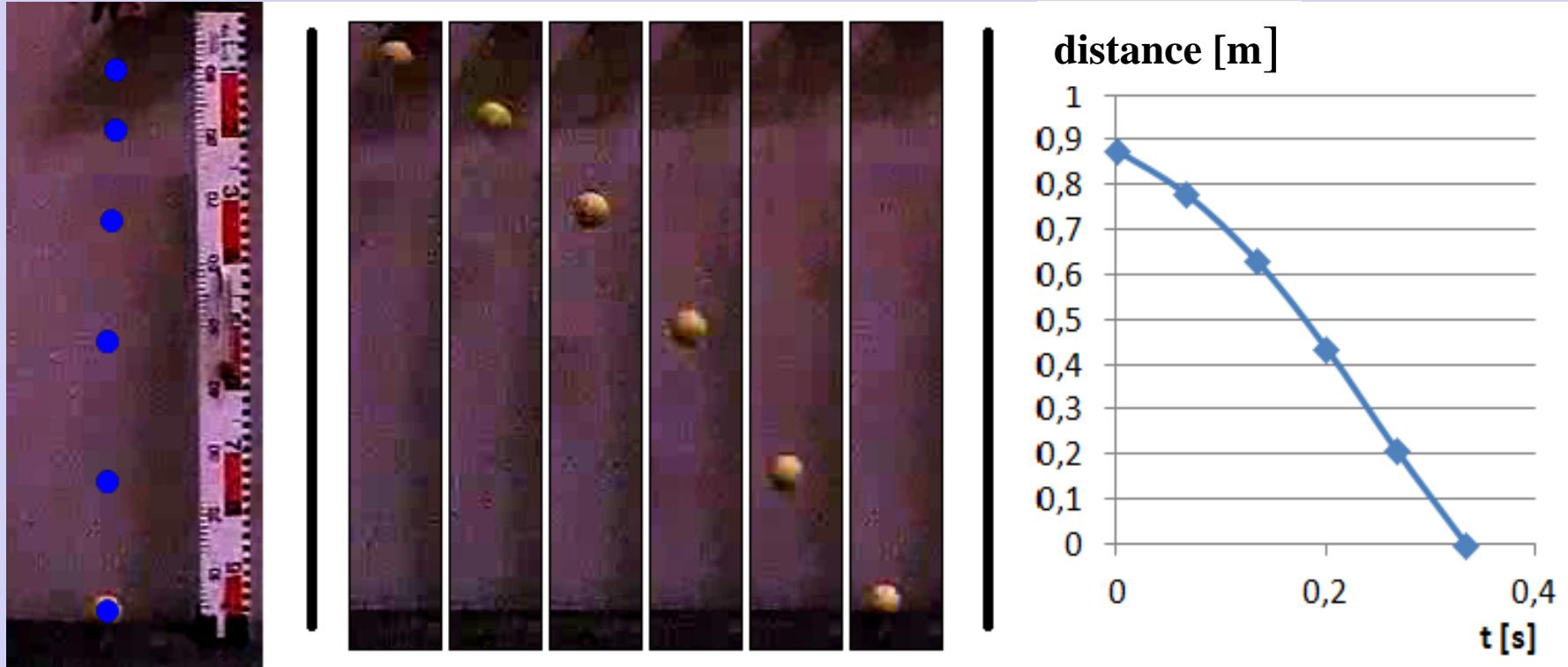




Imprecision in angle

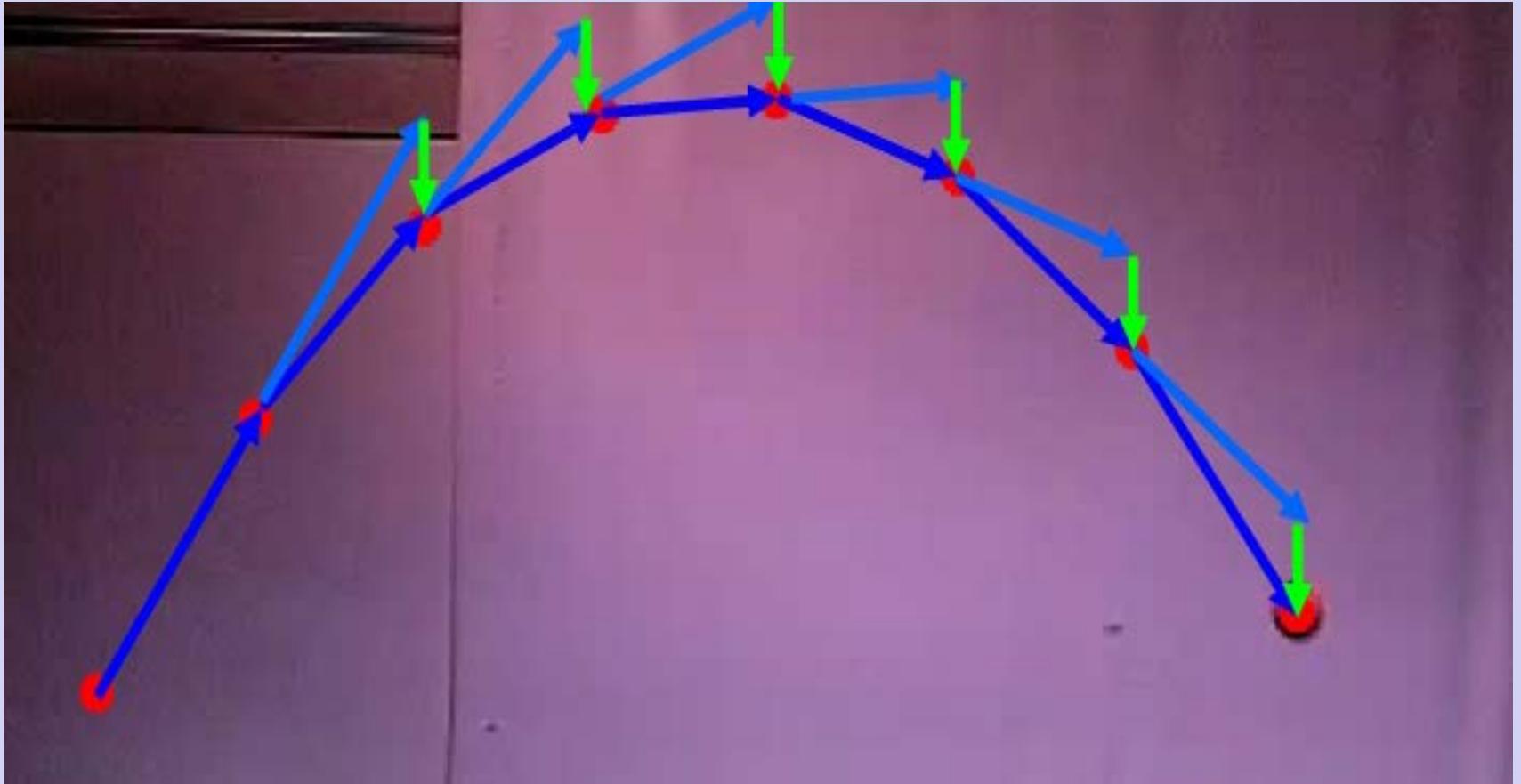


Diagrams



G. Kreuzgruber, diploma thesis, Univ. Graz, 2013

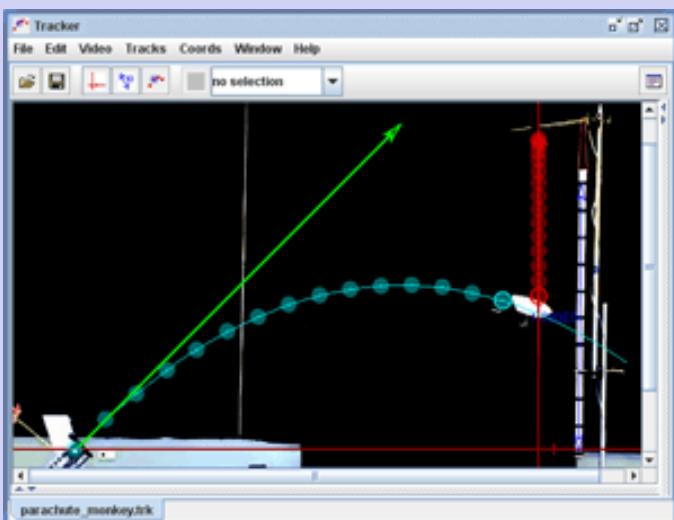
Vectors



G. Kreuzgruber, diploma thesis, Univ. Graz, 2013
measure Dynamics, phywe



<http://www.didaktik.physik.uni-due.de/viana/>



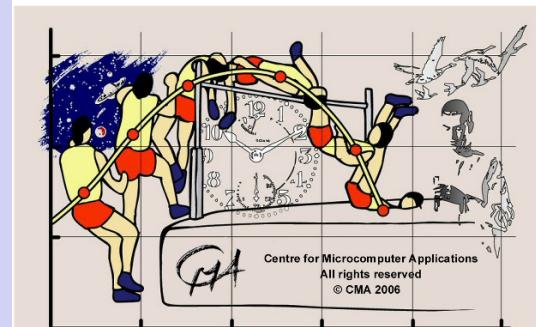
<http://www.opensourcephysics.org/webdocs/Tools.cfm?t=Tracker>

Logger Pro



<http://www.vernier.com/>

Coach6

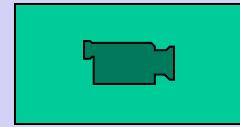


<http://cma-science.nl/software/coach6/>

Interdisciplinary teaching

Billiard

non-central collision



Mathematics

Conservation of energy

$$\frac{1}{2}m \cdot V^2 = \frac{1}{2}m \cdot v_1^2 + \frac{1}{2}m \cdot v_2^2$$

Conservation of momentum

$$m \cdot \vec{V} = m \cdot \vec{v}_1 + m \cdot \vec{v}_2$$

Mathematics

Conservation of energy

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Conservation of momentum

$$m \cdot \vec{V} = m \cdot \vec{v}_1 + m \cdot \vec{v}_2$$

$$\boxed{\begin{aligned} V^2 &= v_1^2 + v_2^2 \\ V^2 &= v_1^2 + 2\vec{v}_1 \cdot \vec{v}_2 + v_2^2 \end{aligned}}$$

Mathematics

Conservation of energy

$$\frac{1}{2}m \cdot V^2 = \frac{1}{2}m \cdot v_1^2 + \frac{1}{2}m \cdot v_2^2$$

Conservation of momentum

$$m \cdot \vec{V} = m \cdot \vec{v}_1 + m \cdot \vec{v}_2$$

$$\begin{aligned} V^2 &= v_1^2 + v_2^2 \\ V^2 &= v_1^2 + 2\vec{v}_1 \cdot \vec{v}_2 + v_2^2 \end{aligned}$$



$$\vec{v}_1 \cdot \vec{v}_2 = 0$$

Modeling

High jump on the Moon

Model 1: Same Speed

Conservation of energy

$$\frac{1}{2}m \cdot v^2 = m \cdot g \cdot h$$

$$h = \frac{v^2}{2g}$$



$$h_{\text{Moon}} = 6 h_{\text{Earth}}$$

High jump on the Moon

Model 2: Same Force

$$m \cdot a = F_{leg} - F_{grav} = F_1$$

$$F_{leg} = 2 m \cdot g$$

$$F_1^{Earth} = m \cdot g \quad F_1^{Moon} = \frac{11}{6} \cdot m \cdot g$$

$$v_{Ab}^{Moon} = \sqrt{\frac{11}{6}} \cdot v_{Ab}^{Earth}$$

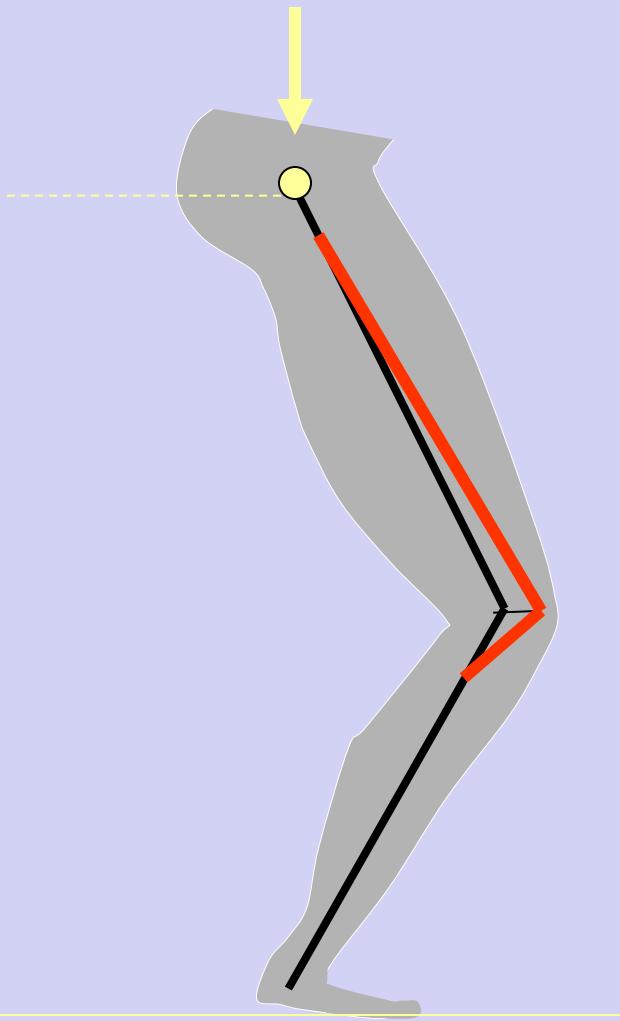
$$h = \frac{v^2}{2g}$$



$$h_{Moon} = 11 h_{Earth}$$

High jump on the Moon

Model 3: Biomechanical Model



muscle

activation

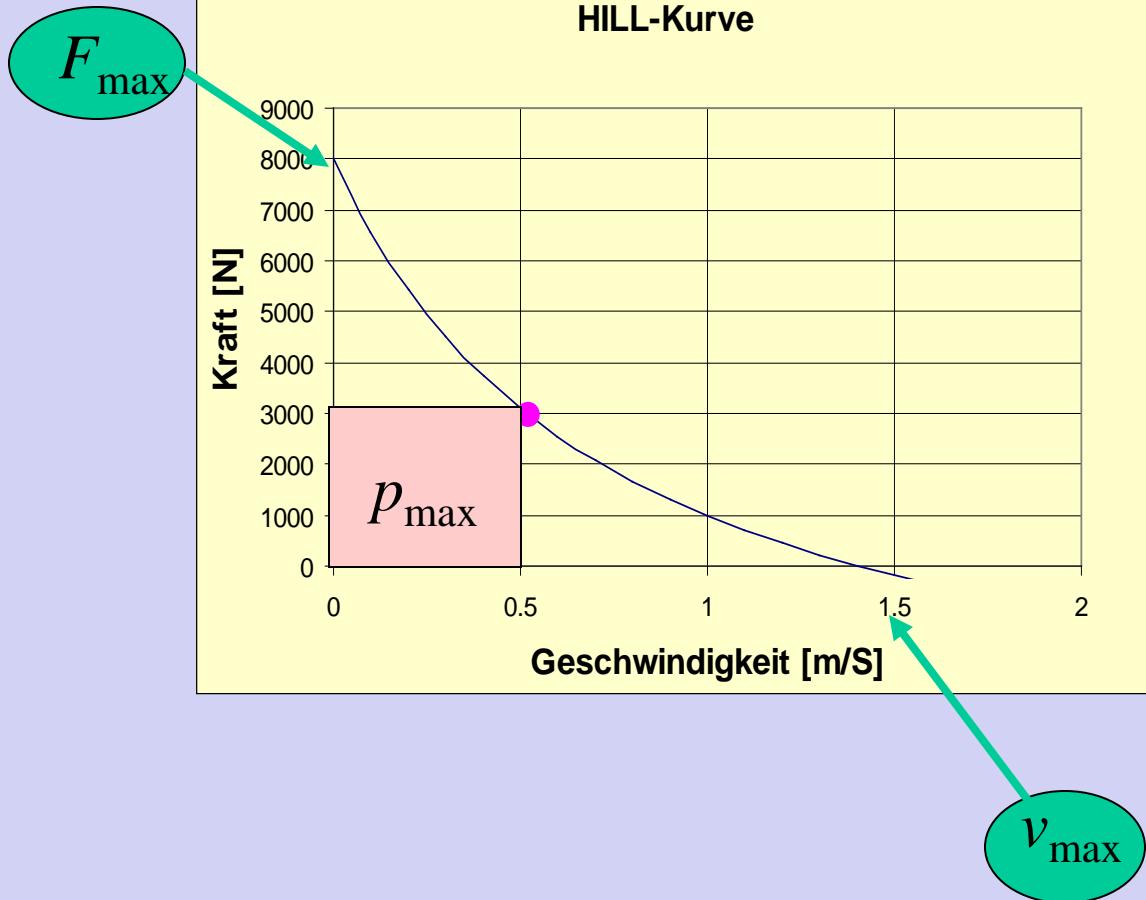
geometry

Spring Muscle

$$F \sim x$$

$$F \sim 1 / v$$

Force of a muscle

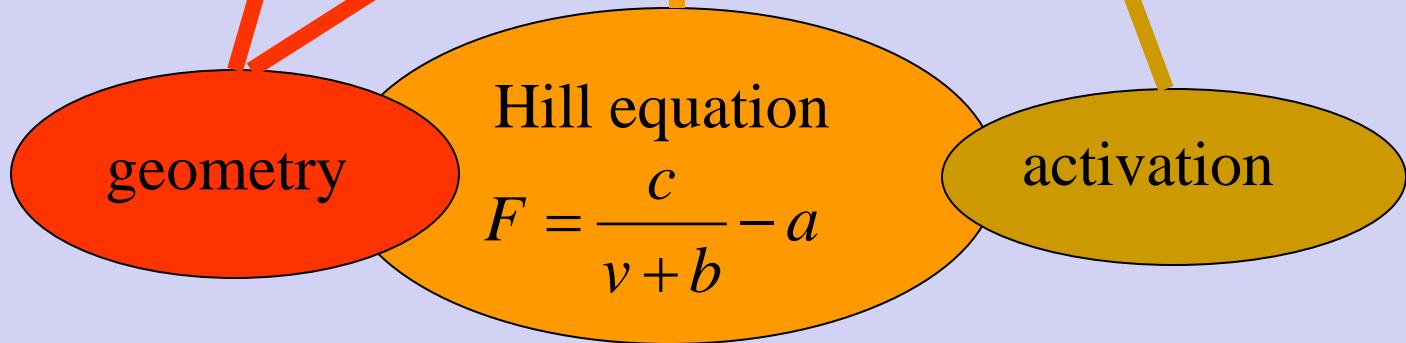


A.V. Hill

$$F = \frac{c}{v + b} - a$$

Equation of motion

$$m \frac{d^2 X}{dt^2} = -mg + G(X) \cdot \left(\frac{c}{G(X) \frac{dX}{dt} + b} - a \right) \cdot S(t)$$

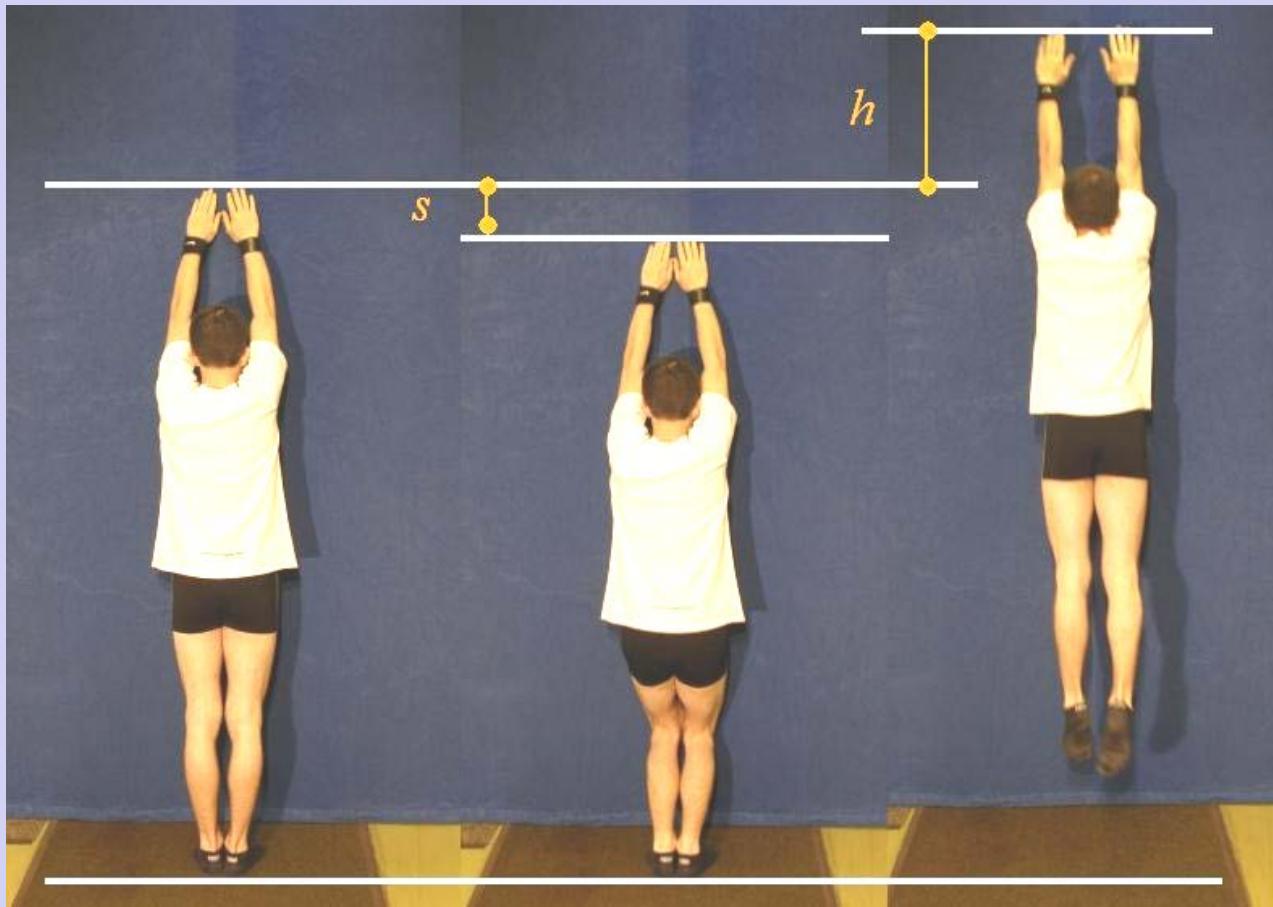


$$h_{\text{Moon}} = 10,5 h_{\text{Earth}}$$

S. Thaller, PhizZ 34(2), 2003, 87

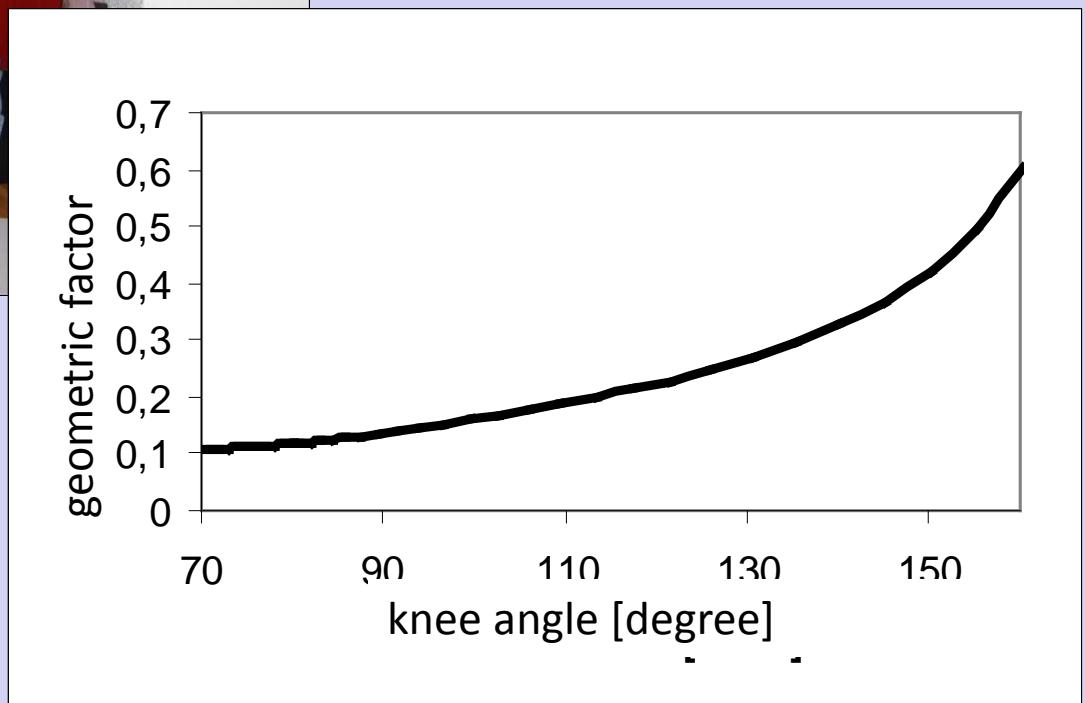
Activity

Force of the legs



$$F_B \cdot s = (h + s) \cdot m \cdot g$$

Geometry

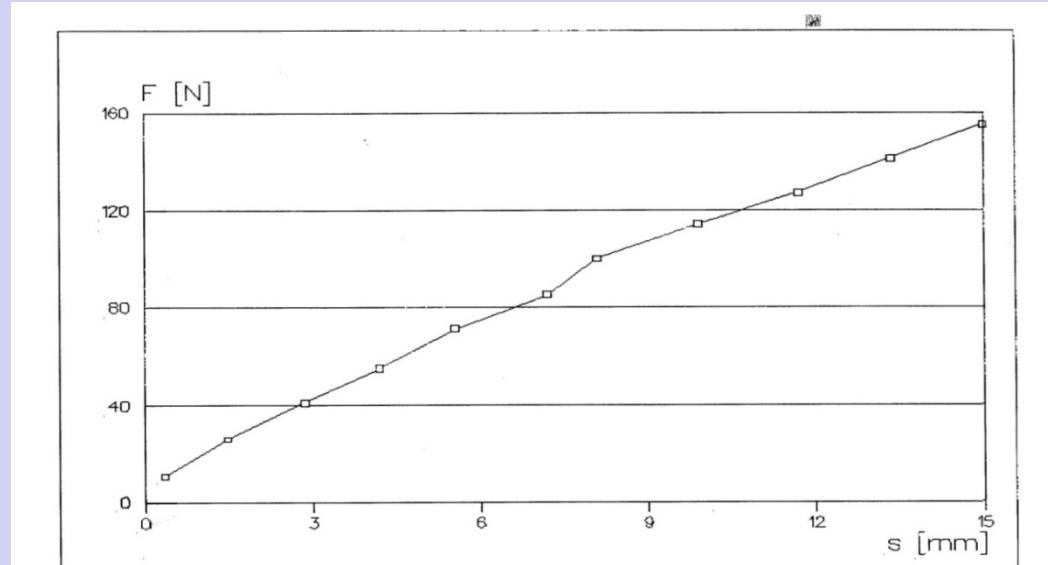
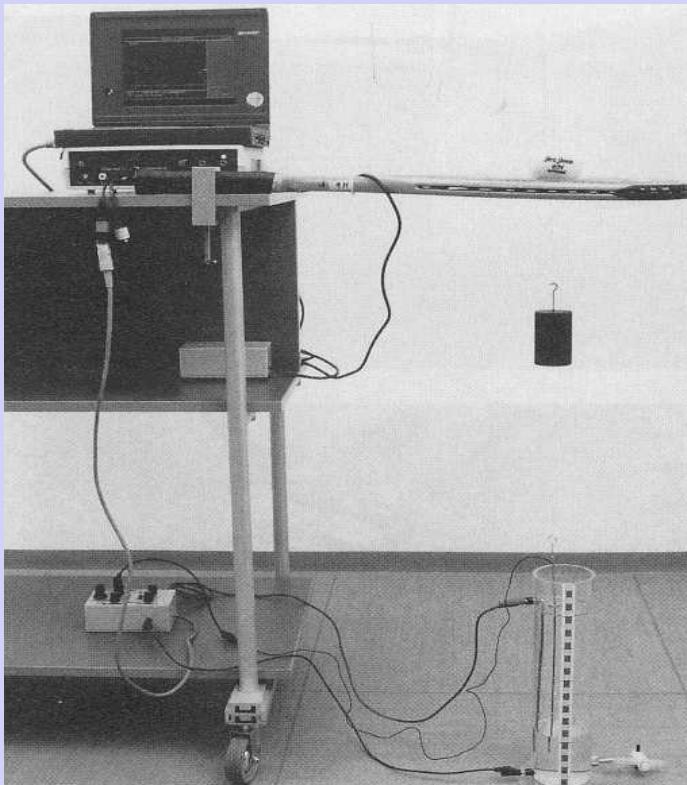




Experiment

Interaction Racket - Ball

Deviation of a racket



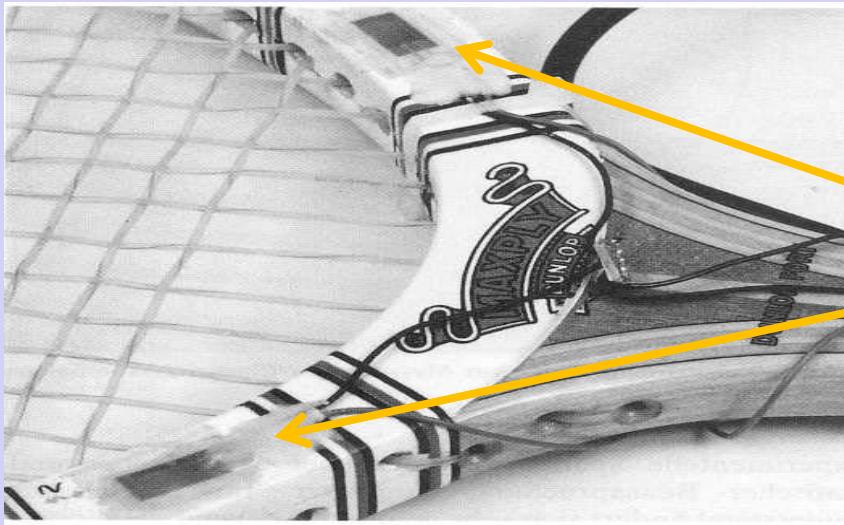
$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$k = 10 \text{ kN/m}$$

$$m = 0,16 \text{ kg}$$

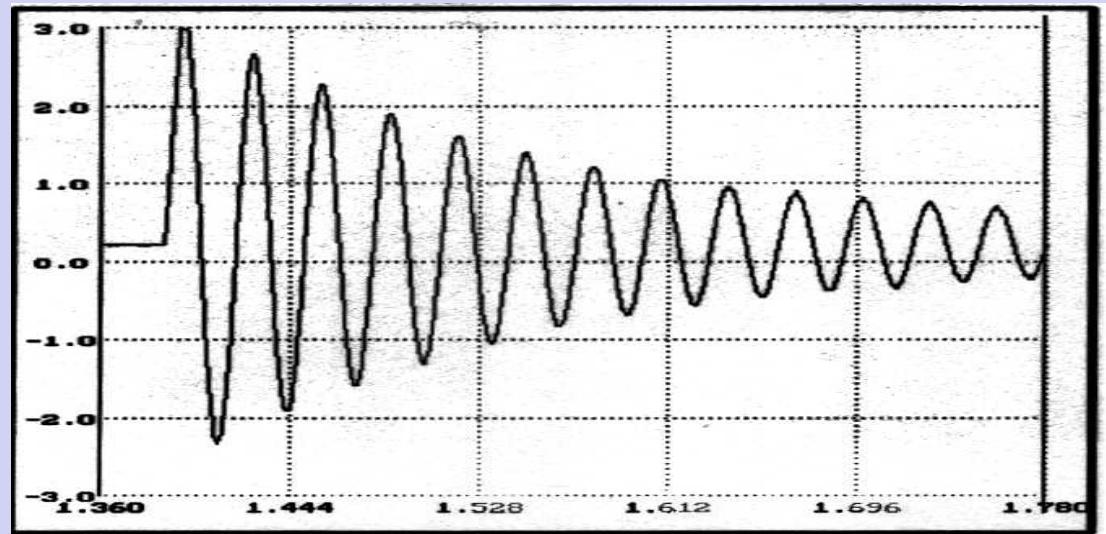
$$T = 0,025 \text{ s}$$

Oscillation of a racket

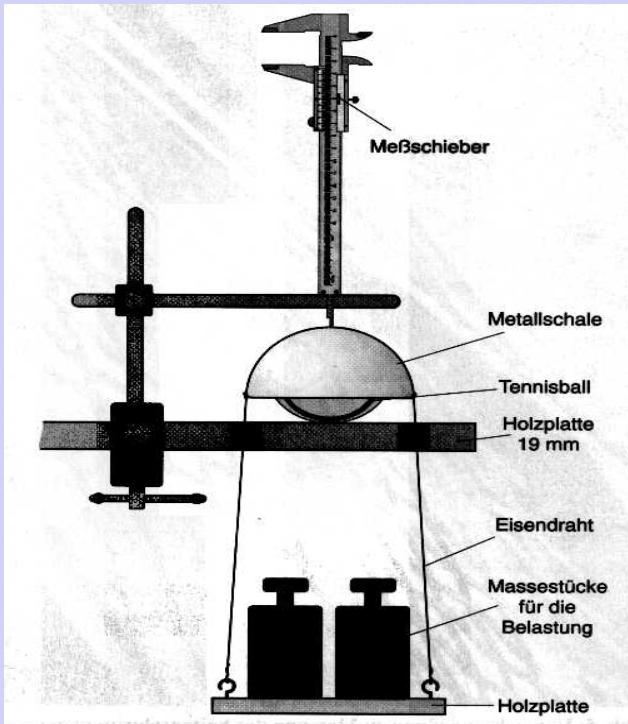


strain gauges

$T = 0,030 \text{ s}$



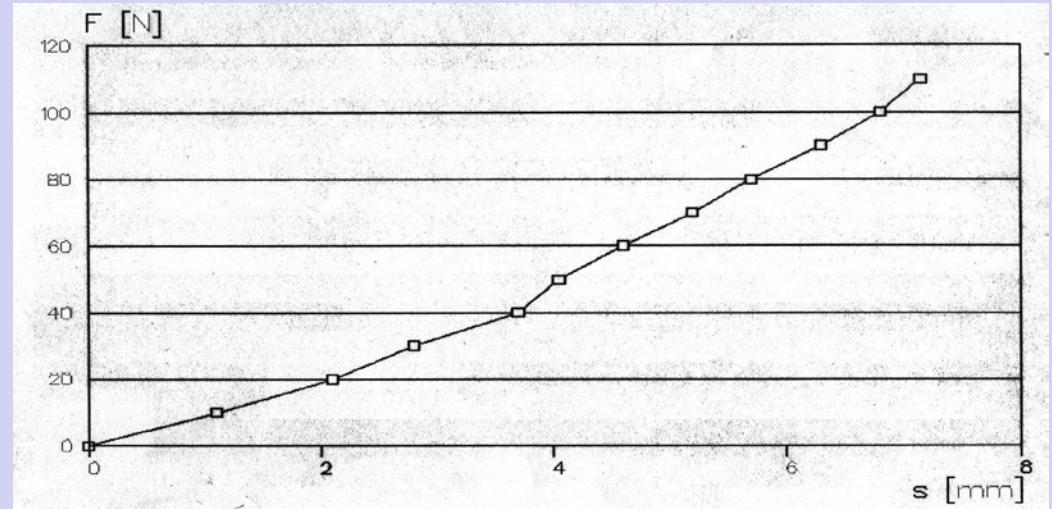
Elasticity of the ball



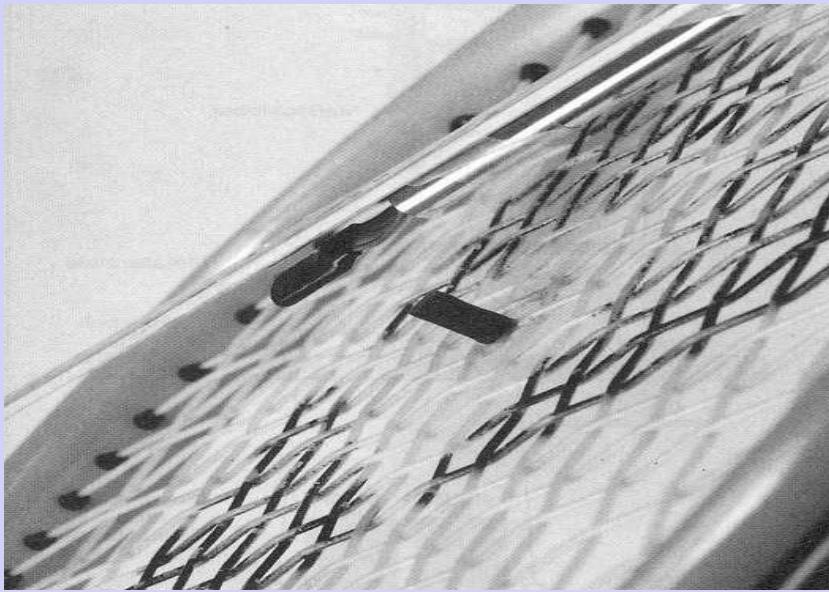
$$T = 0,012 \text{ s}$$

$$k = 15 \text{ kN/m}$$

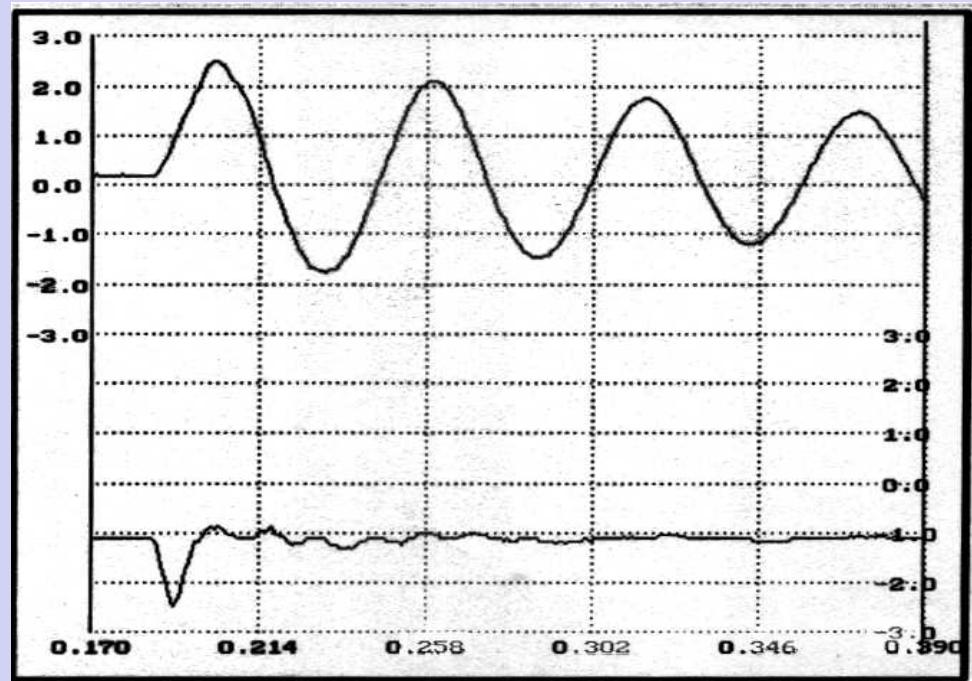
$$M = 0,058 \text{ kg}$$



Oscillation of strings



T = 0,010 s



T. Duenbostl, L. Mathelitsch, T. Oudin, PdN-Ph 45(2), 1996, 2.

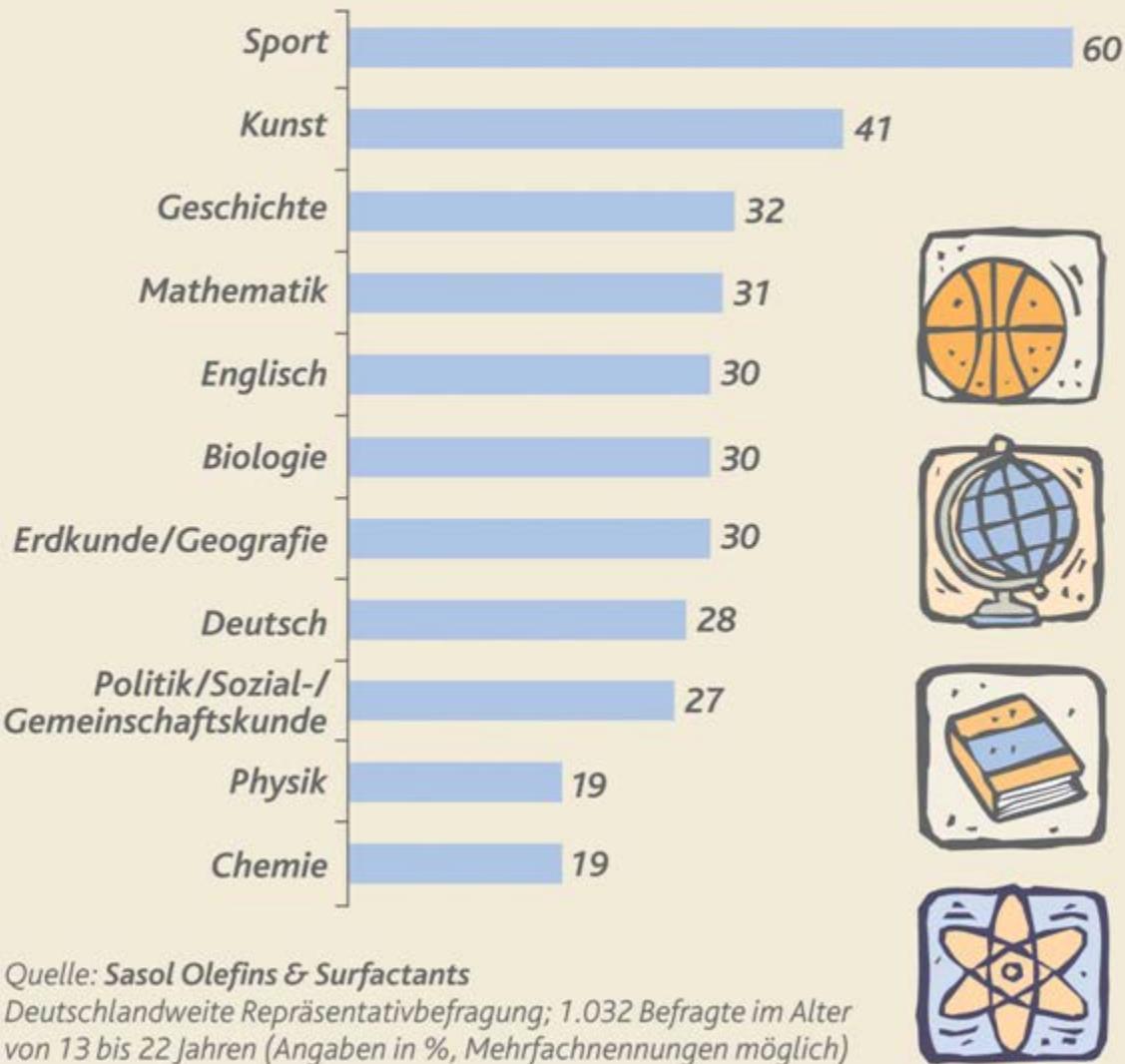
Tennis-racket: old - new



Interest

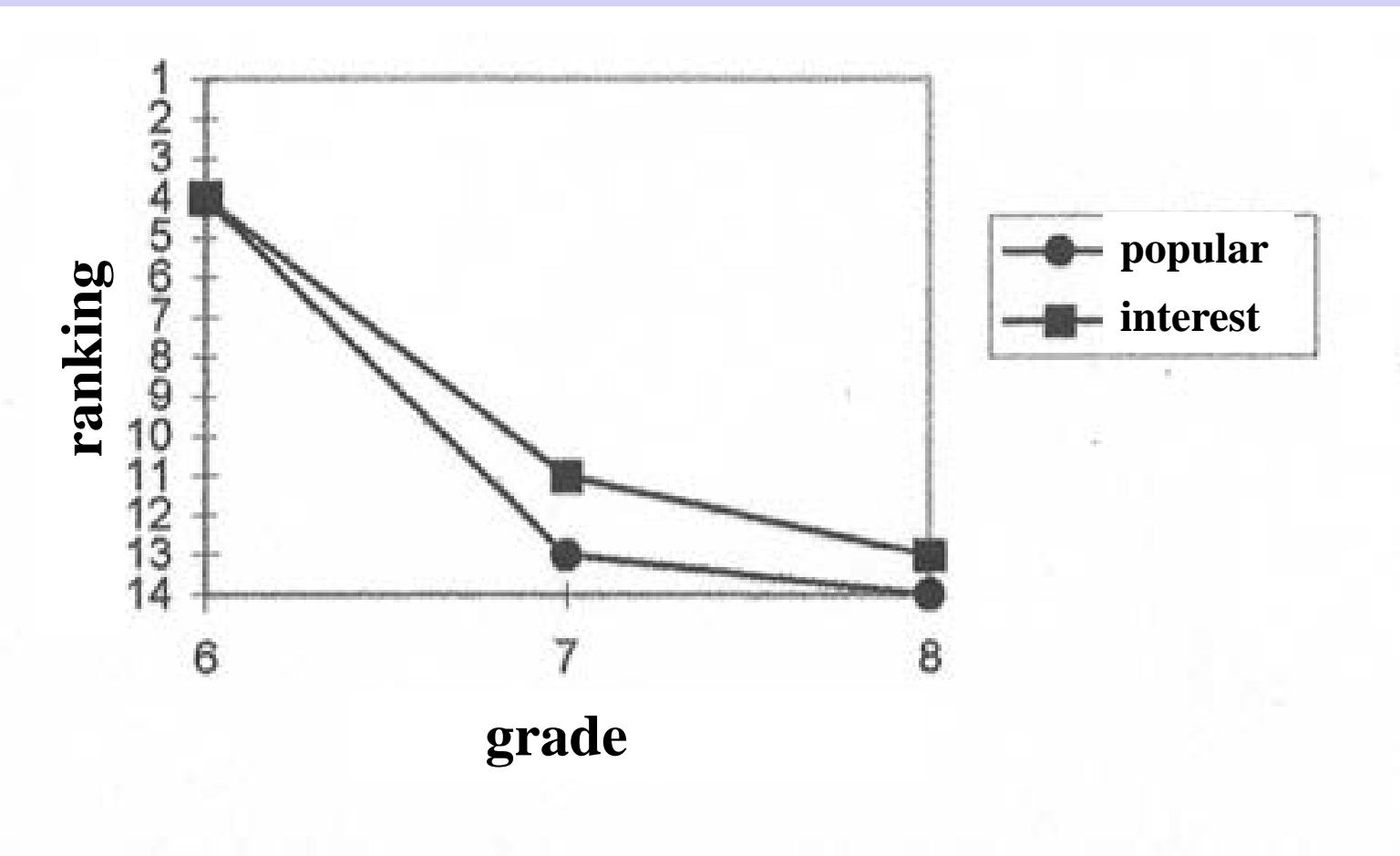
Interest

Die beliebtesten Schulfächer in Deutschland



Source: Sasol Olefin & Surfactants

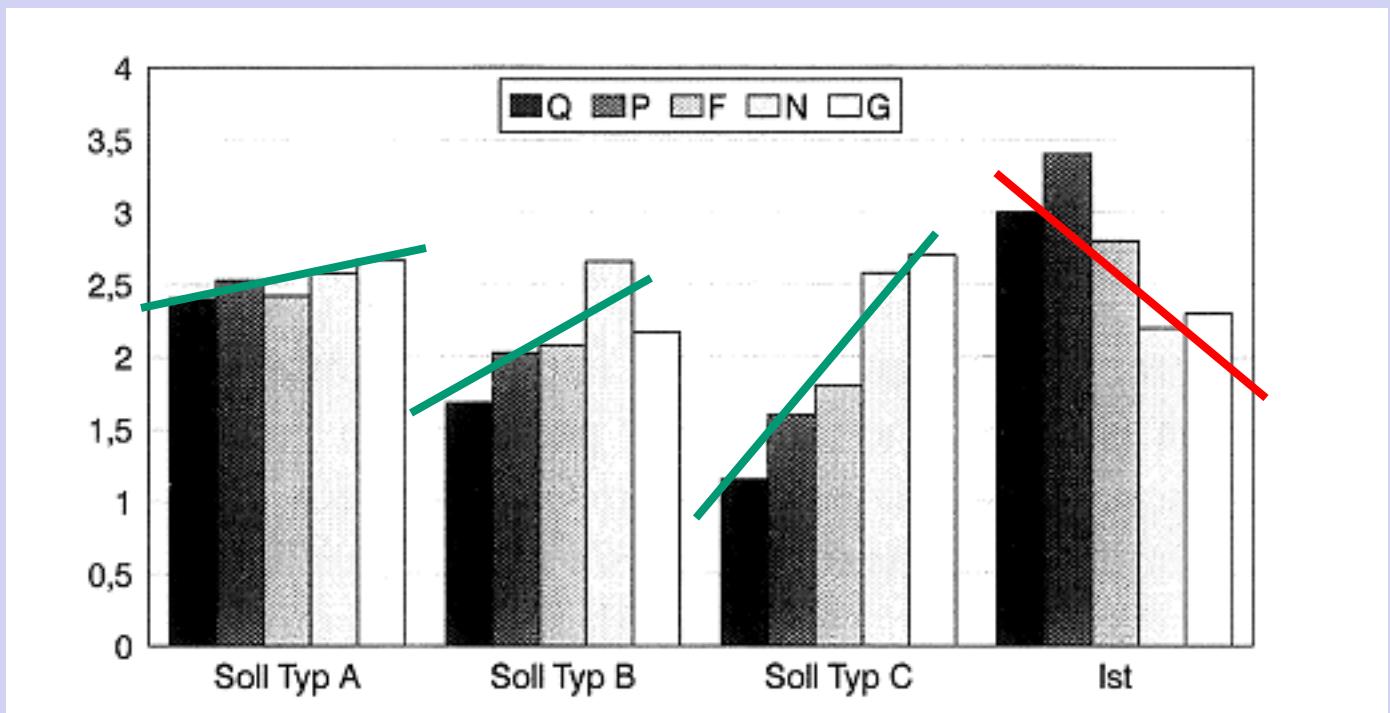
Interest



E. Lex, E. Gunacker, plus lucis 1/98

Interest

P. Häussler et al.
ZfDN 2(3), 1996,
57



- A interested in physics
- B medium interest
- C not interested

Q	quantitative physics
P	qualitative physics
F	technical applications
N	natural phenomena
G	physics and society

Soccer



Poisson distribution

$$P_k(a) = \frac{a^k}{k!} e^{-a}$$

a average number of goals
k number of goals
 $P_k(a)$ probability to score k goals

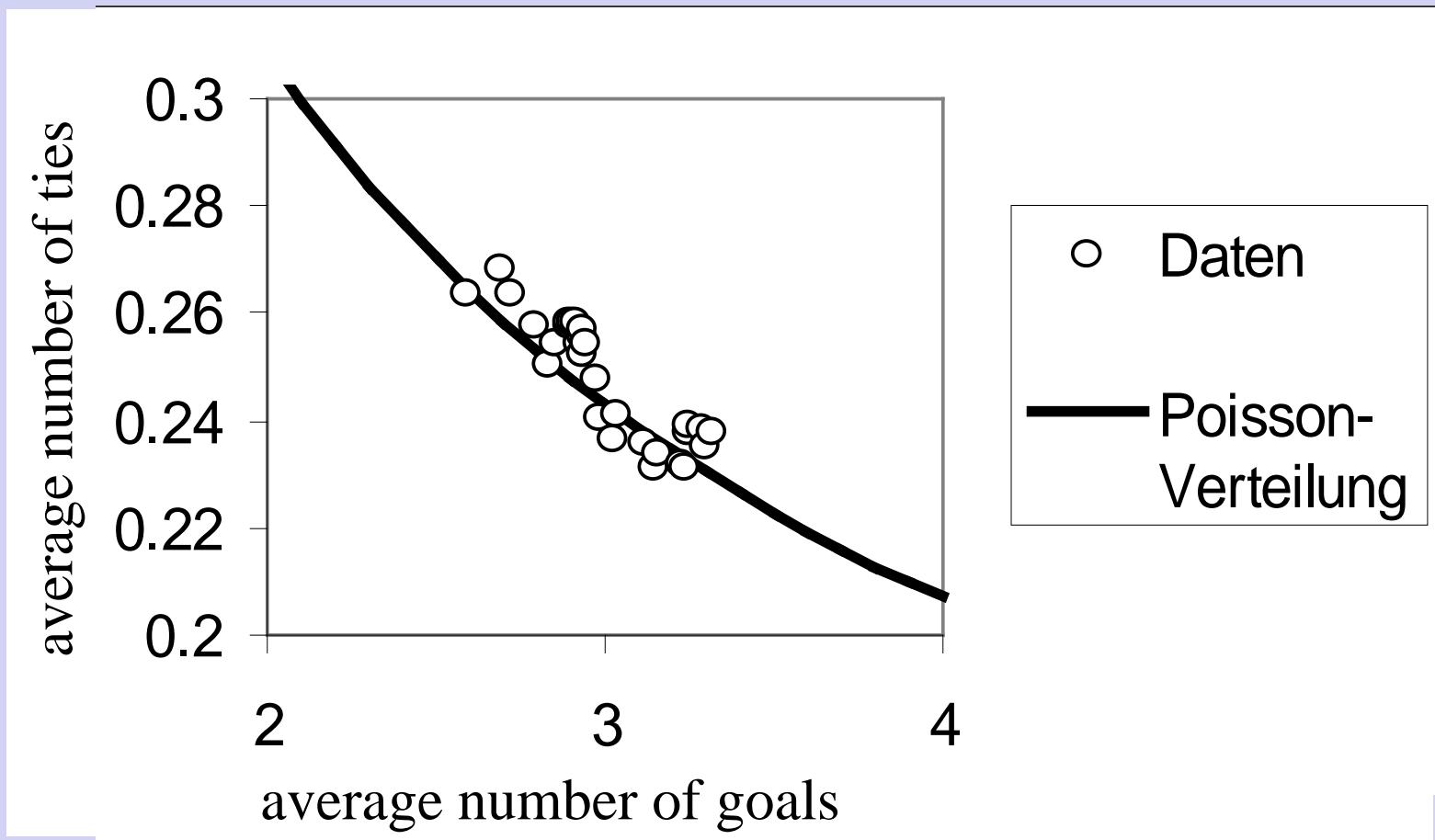
Probability of goals / results

Quellenstärke a = 2	
$P_0(2) = e^{-2}$	0,135
$P_1(2) = 2e^{-2}$	0,270
$P_2(2) = 4e^{-2} / 2$	0,270

$$\begin{aligned}P_3(2) &= 8e^{-2} / 6 \\P_4(2) &= 16e^{-2} / 24\end{aligned}$$

Quellenstärke a = 2	
Ergebnis	Prozent
0:0	1,8
1:0, 0:1, 2:0, 0:2	3,4
1:1, 2:1, 1:2, 2:2	7,3
3:0, 0:3	2,4
3:1, 1:3, 3:2, 2:3	4,9
3:3	3,2
4:1, 1:4, 4:2, 2:4	2,4

Theory – Experiment



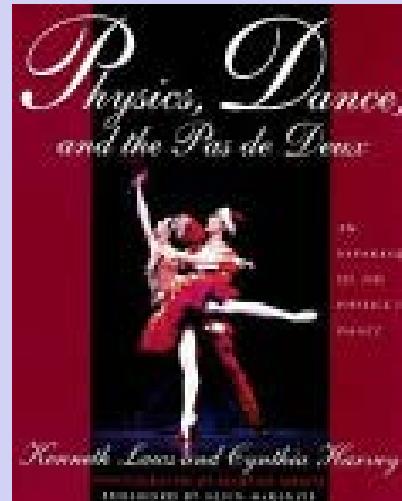
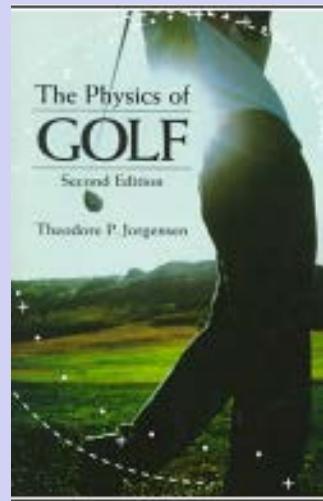
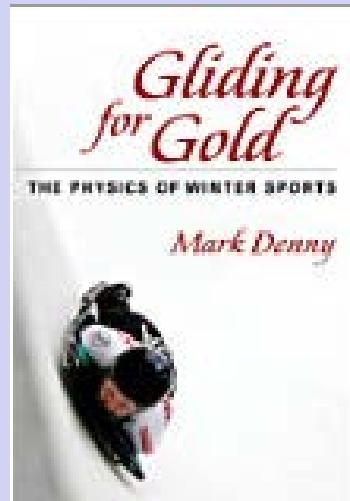
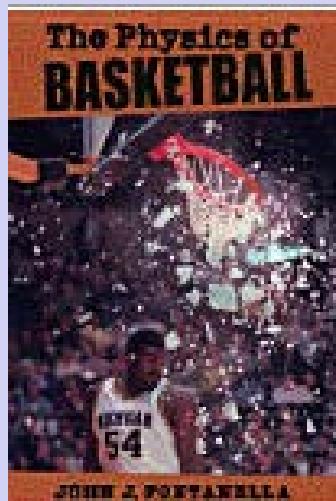
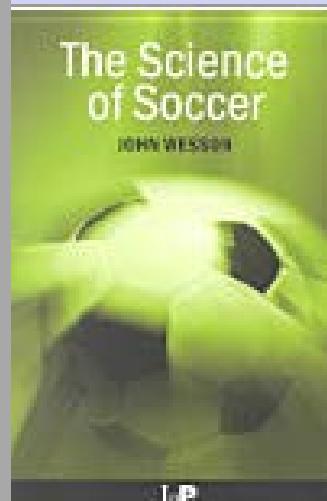
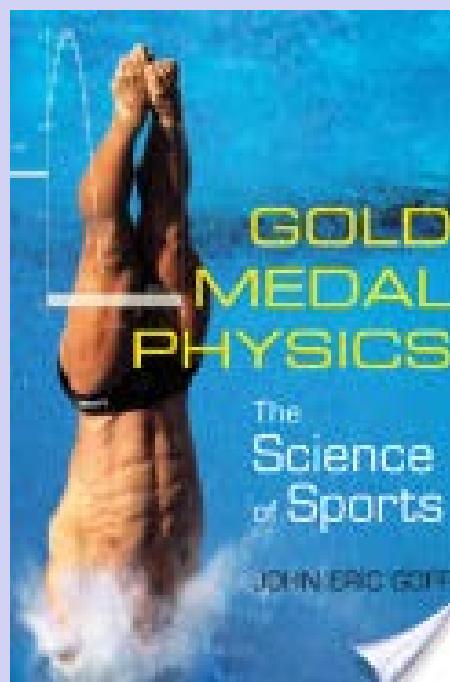
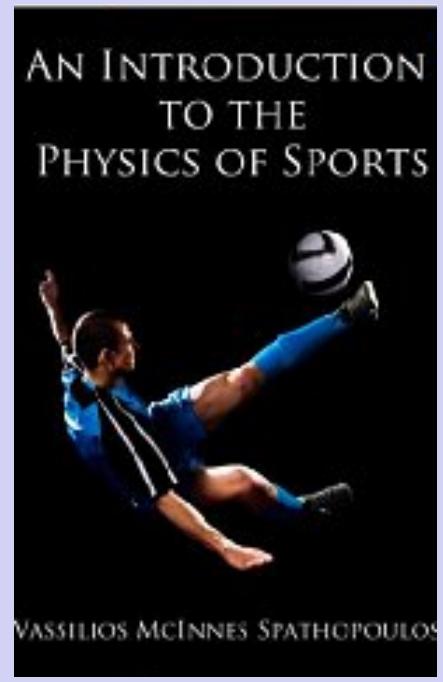
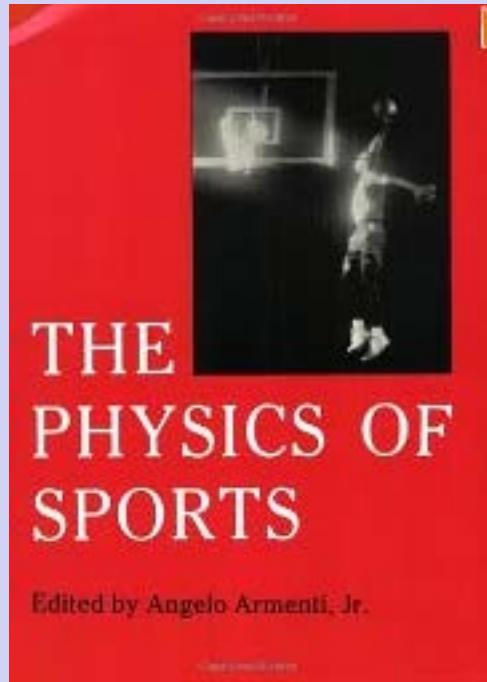
L. Mathelitsch, S. Thaller, PhuZ 37(3), 206, 123

Soccer – pure chance?



TOTO

Literature



ICPE-EPEC 2013

UNI
GRAZ

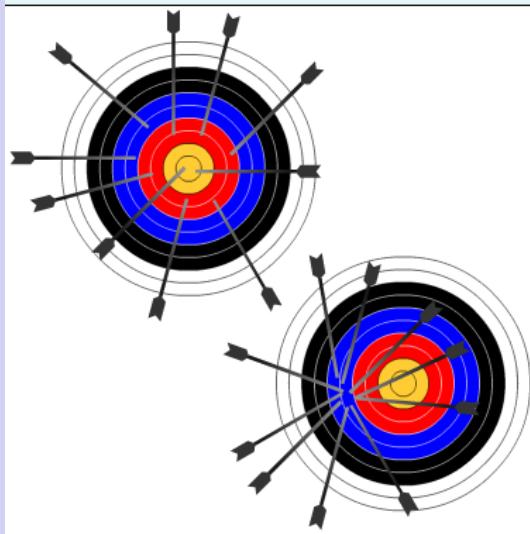




National
Teaching
Fellowship
Scheme

R. Lambourne
Open University

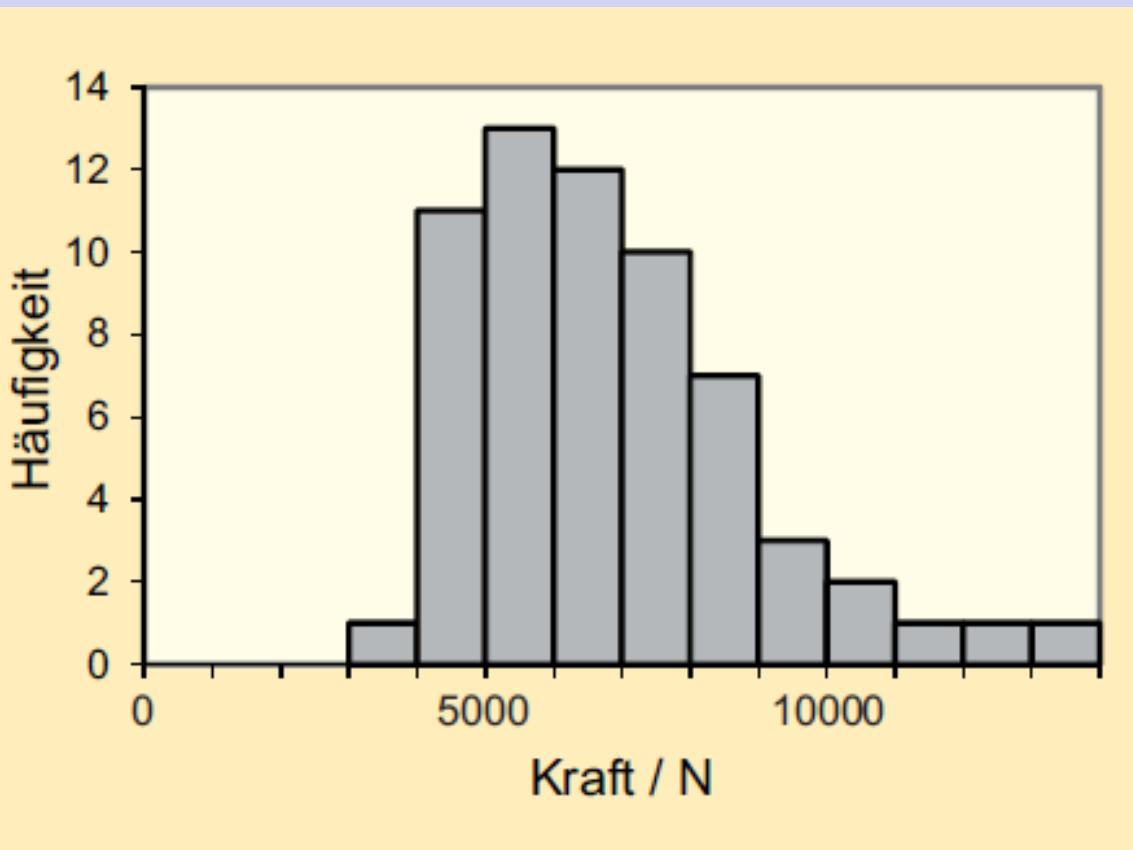
E-Learning in Physical Science through Sport - ELPSS



Accuracy and Precision

Curiosity

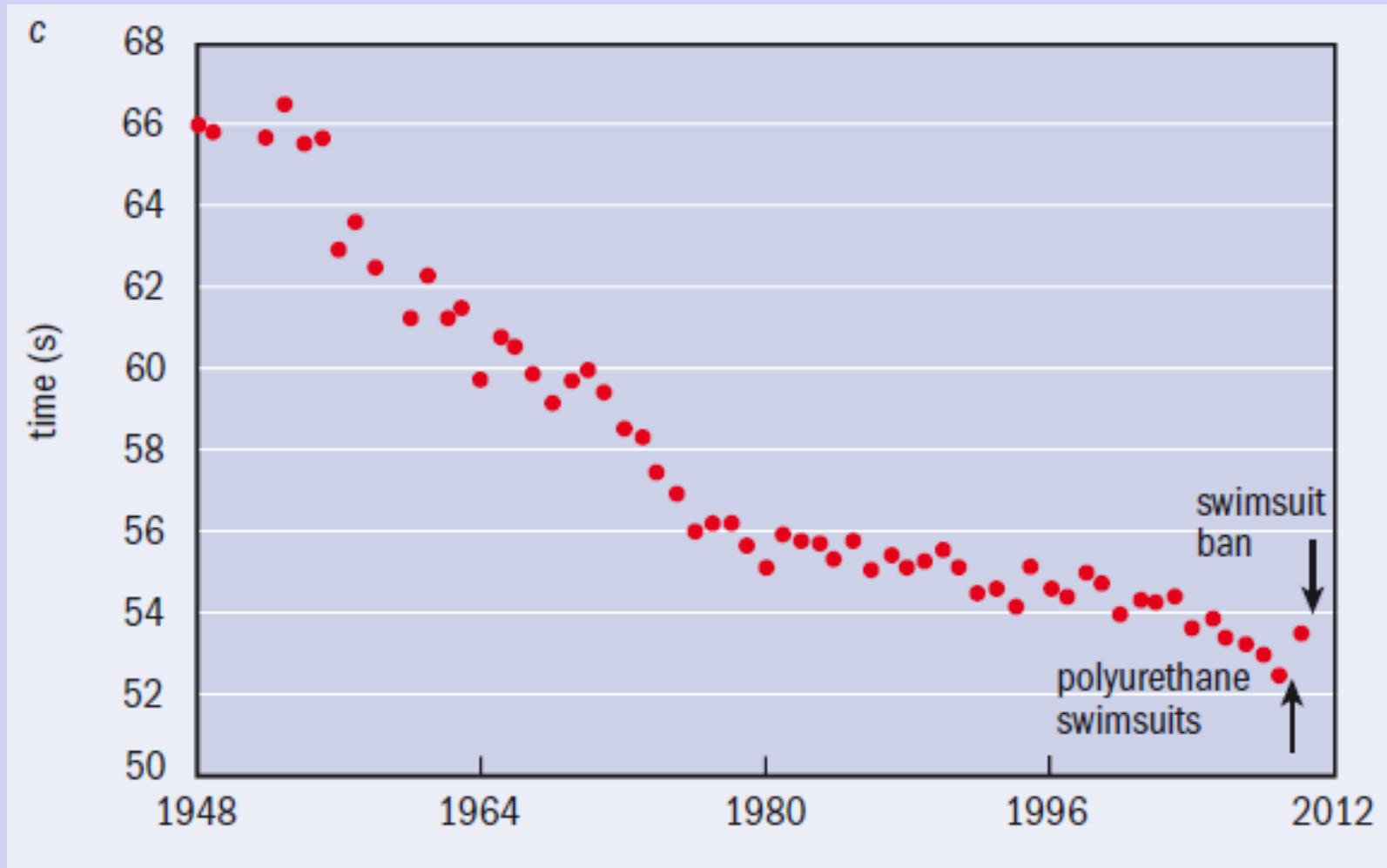
Records



Statistical Distribution

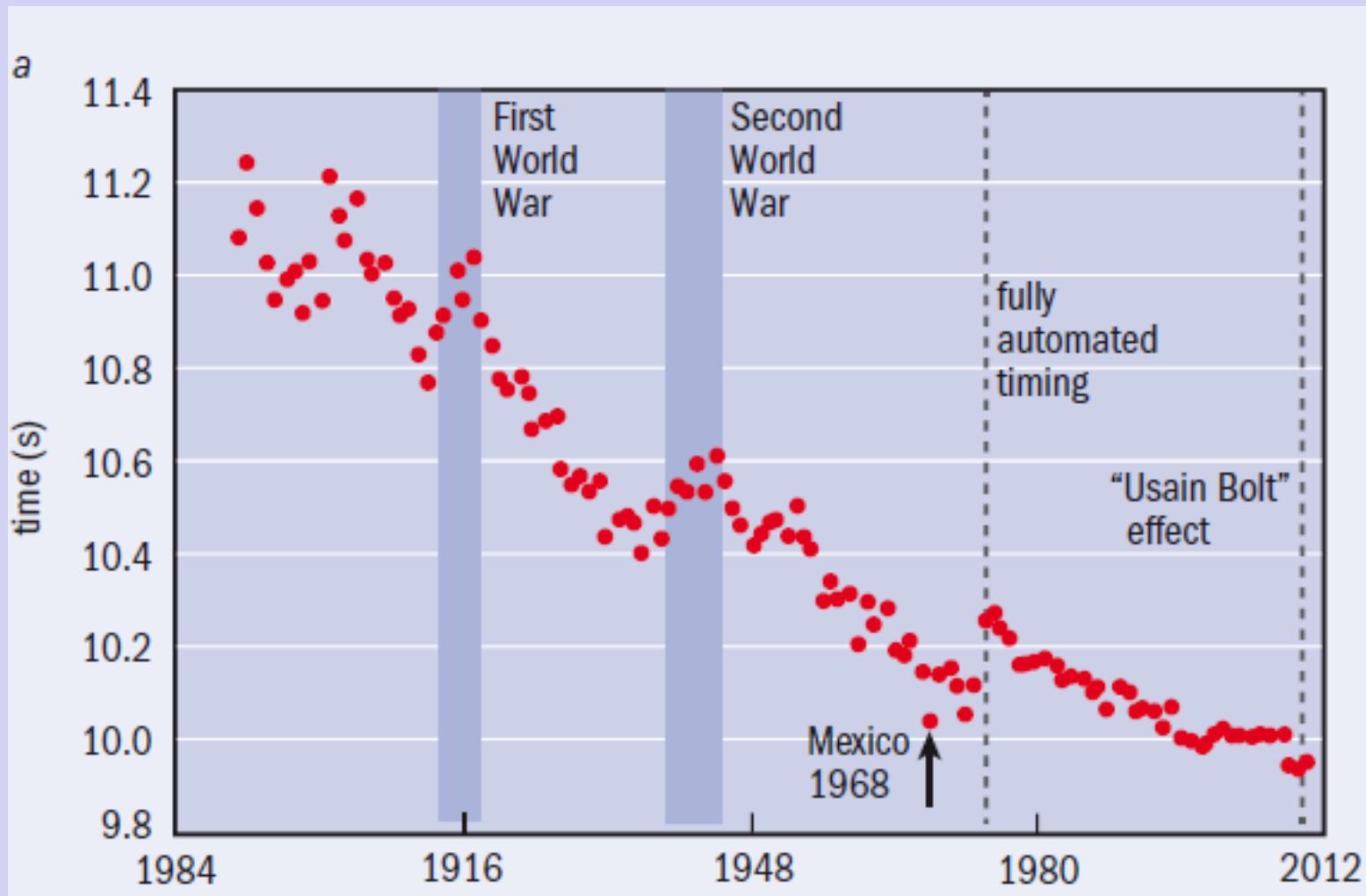
L. Mathelitsch, S. Thaller, PhuZ 43(4), 2012, 186

100 m freestyle women



S. Haake „Material advantage?“ Physics World, July 2012, p. 26

100 m dash men

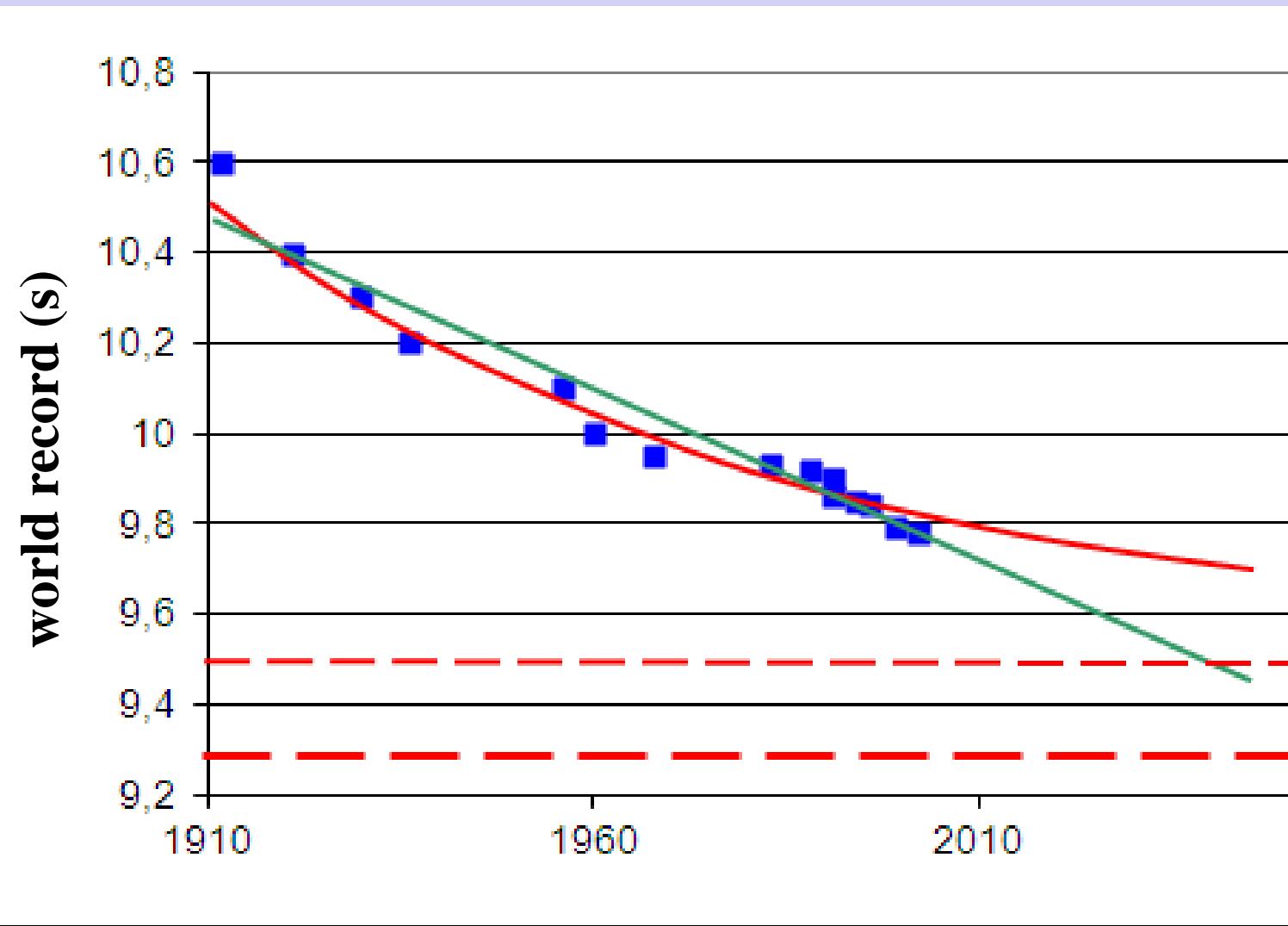


S. Haake „Material advantage?“ Physics World, July 2012, p. 26

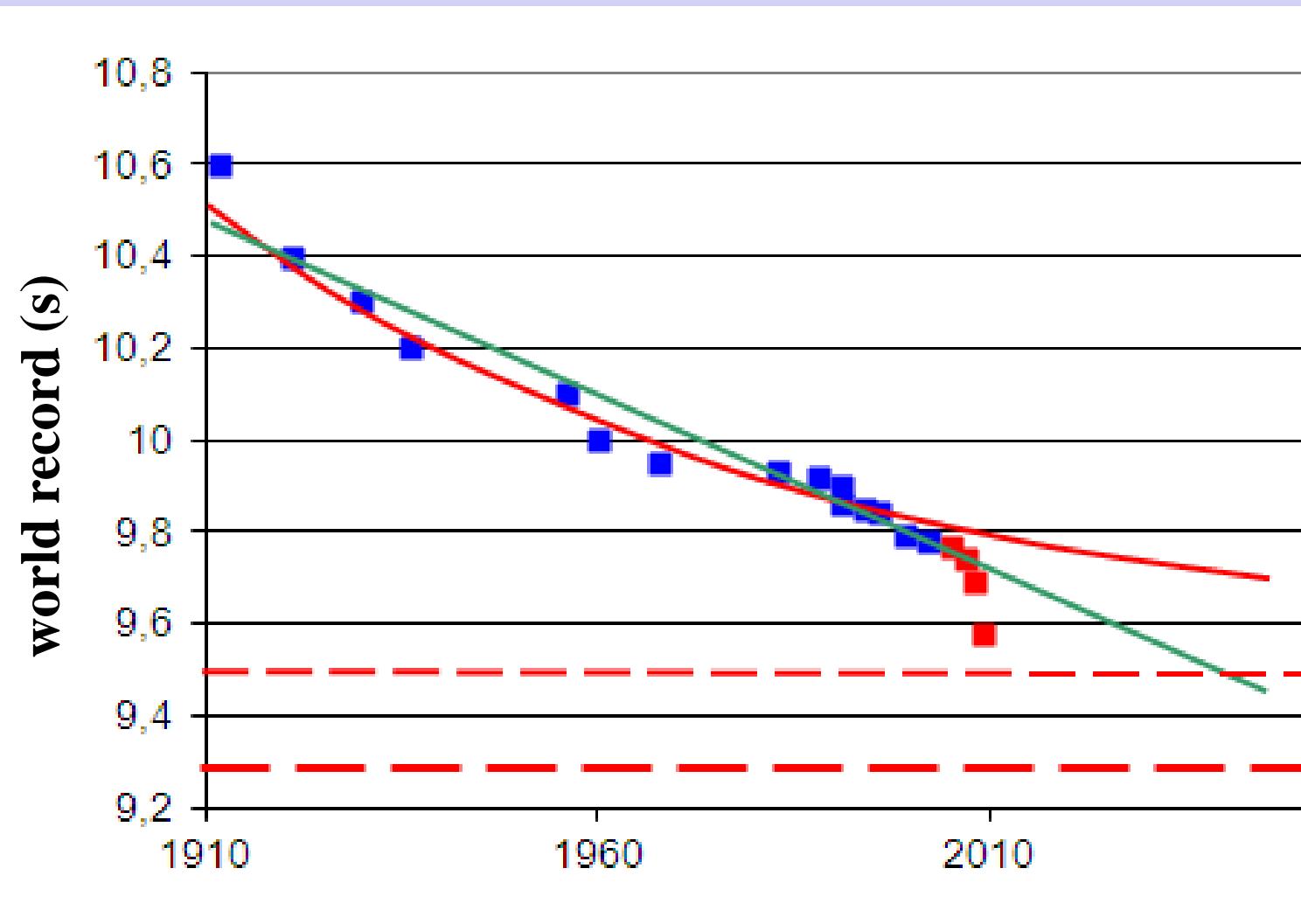
ICPE-EPEC 2013

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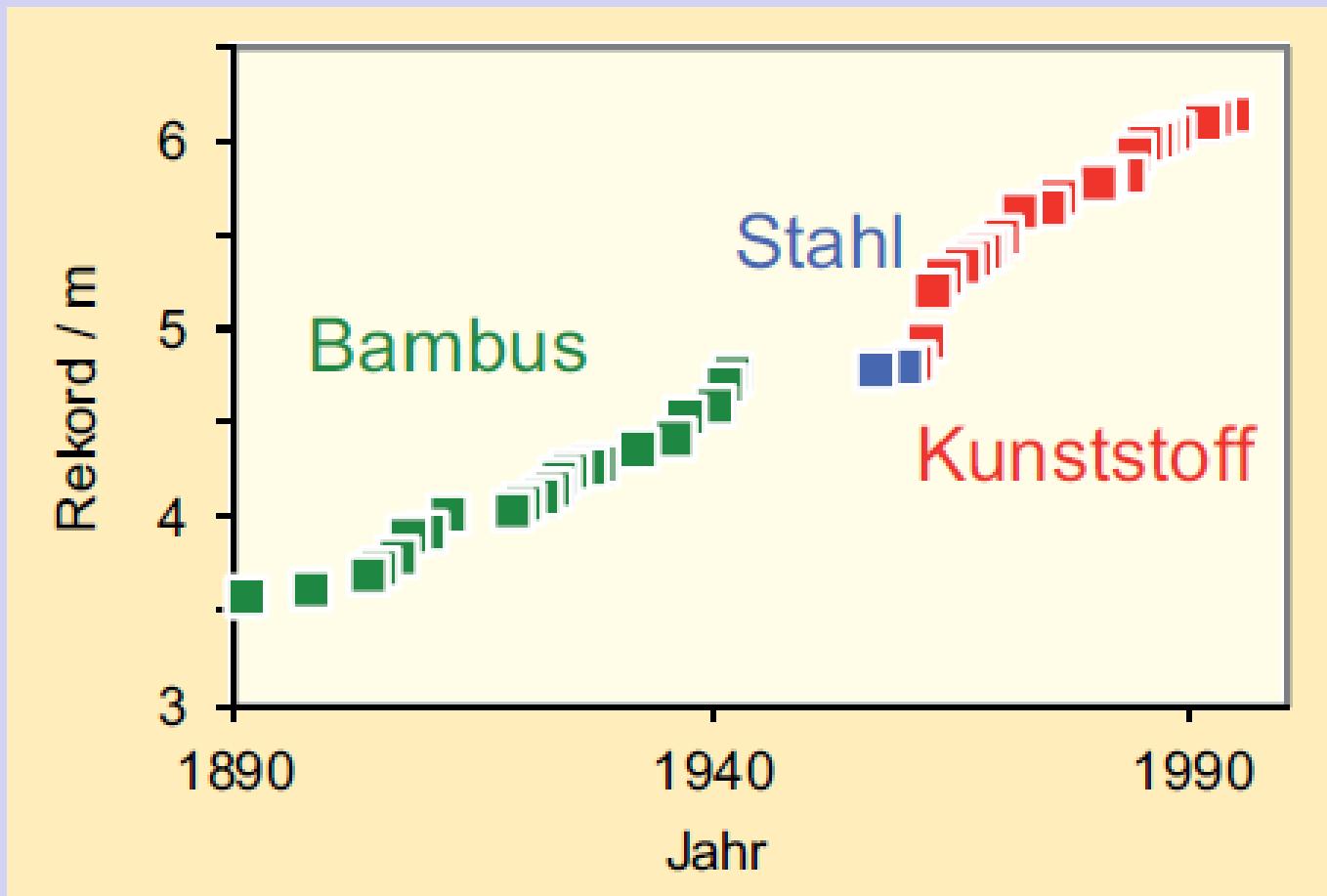
100 m dash men



100 m dash men



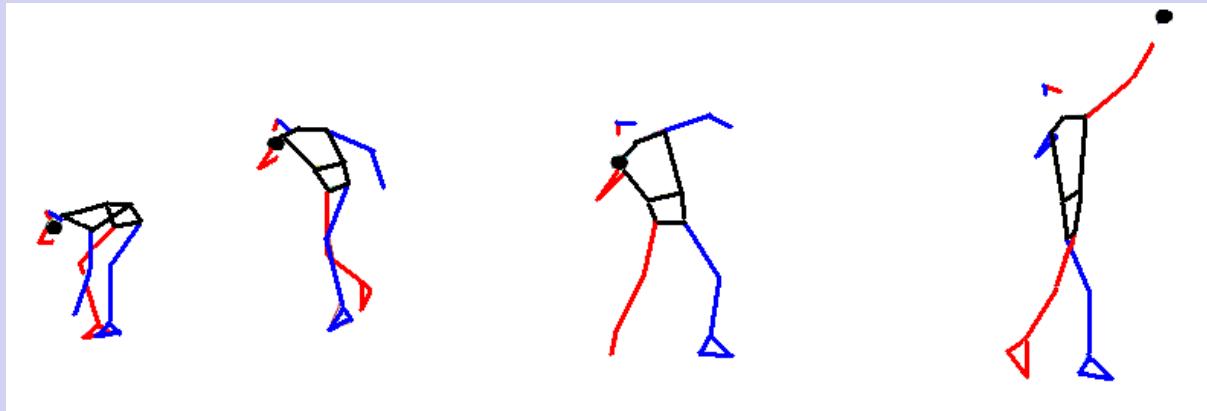
Pole vault



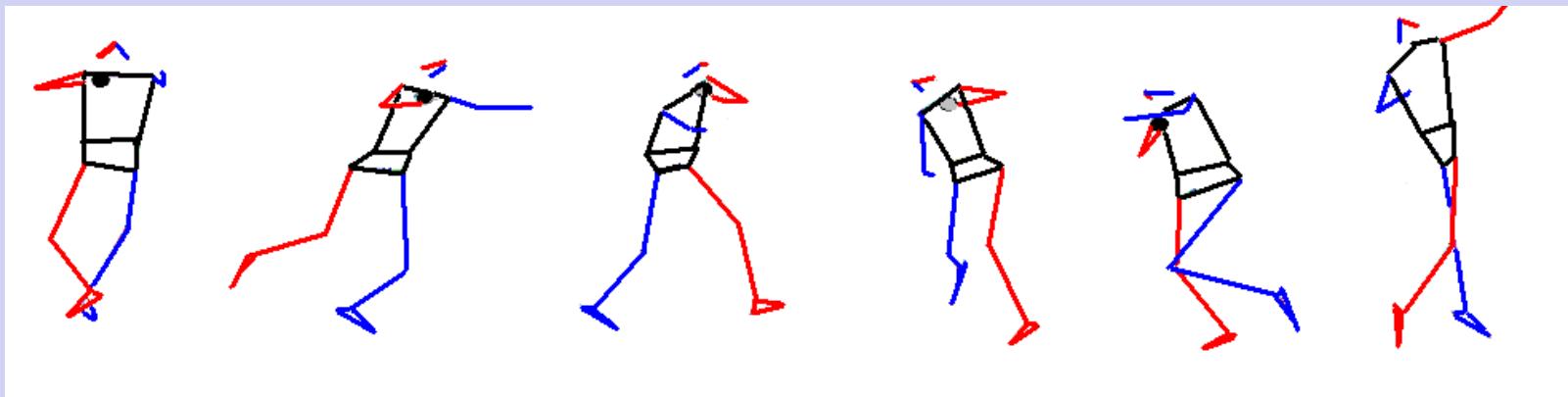
L. Mathelitsch, S. Thaller, PhiuZ 43(4), 2012, 186

Shotput

O'Brien technique

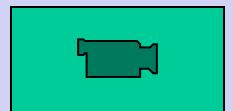
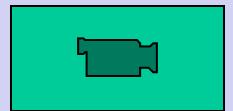
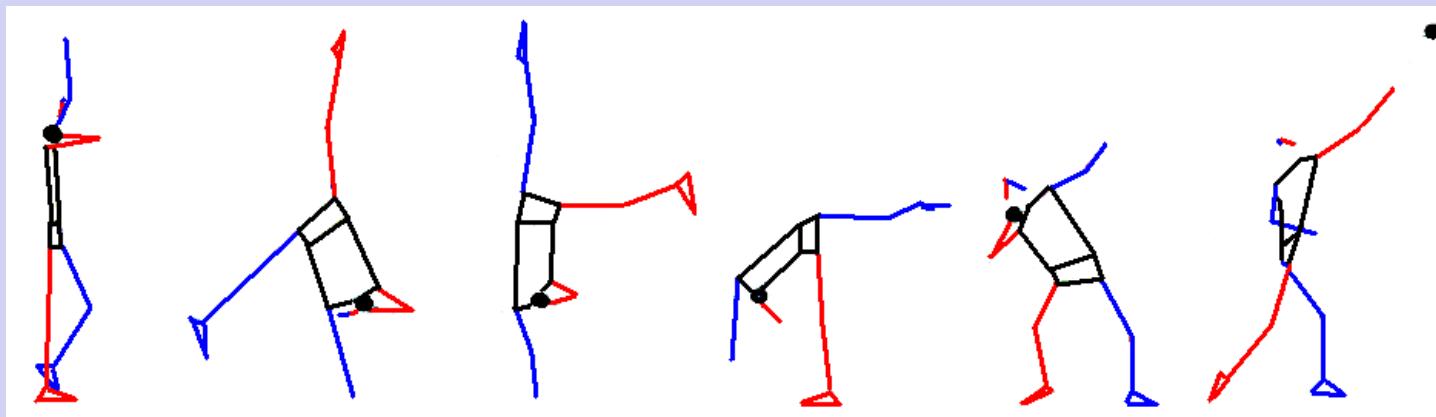


Spintechique



Shotput - new

Cartwheel-technique



L. Mathelitsch, S. Thaller, Sport und Physik, Aulis
Verlag Deubner, Köln 2008

Thanks

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