Physik im Prater und Spielplatz

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fysik.org

Lise Meitner in Kungälv
(close to Göteborg)

KUNGÄLVS KOMMUN

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

Lise-Meitner Prize, Chalmers

Remembering Miss Meitner

A one-act play by Robert Marc Friedman

Performed by the original cast from
Göteborg Theatre, Sweden

Inger Hayman as Lise Meitner
Ingemar Carlehed as Otto Hahn
Johan Karlberg as Manne Siegbahn

Directed by **Christel Körner**

Friday, January 16 8:00 pm

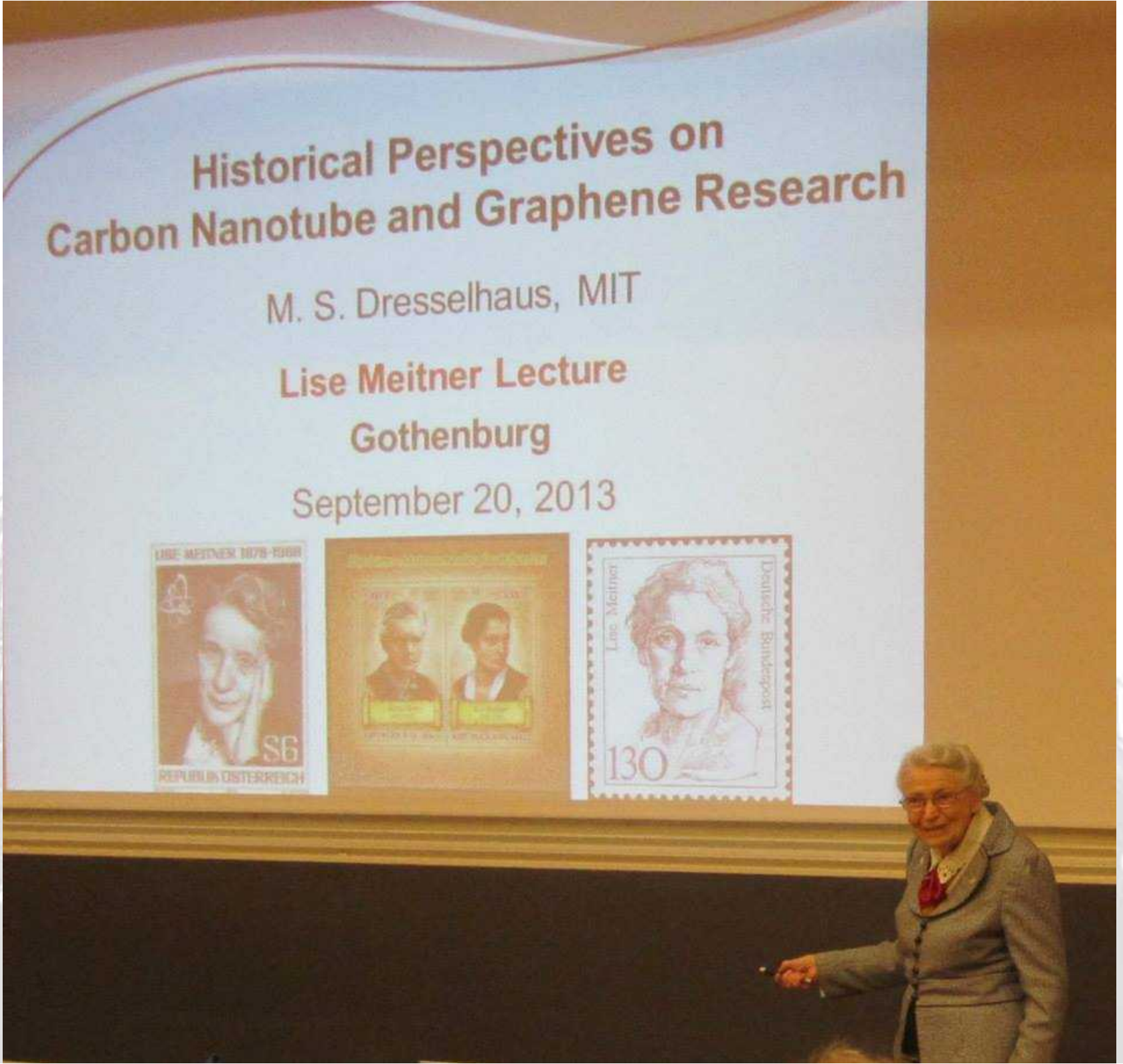
Saturday, January 17 8:00 pm

The New Theater, 1156 Chapel Street

Admission is free but reservations are required.

Please reserve your seat at: catherine.barabas@yale.edu

Sponsored by: Yale University Department of Physics, Jonathan Edwards College, the Provost Office of Yale University, the School of Engineering, and the Women Faculty Forum.


Historical Perspectives on
Carbon Nanotube and Graphene Research
M. S. Dresselhaus, MIT
Lise Meitner Lecture
Gothenburg
September 20, 2013
S6
REPUBLIK ÖSTERREICH
Lise Meitner
Deutsche Bundespost
130

Physik im Prater

...

Statics and loads in the Riesenrad?

(More about dynamics)

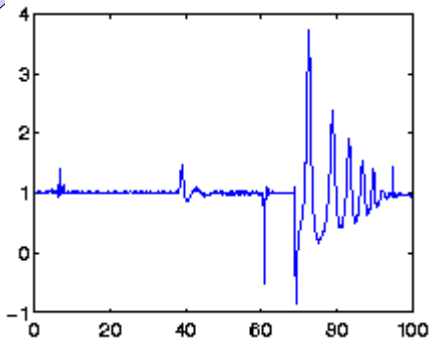
Physics for many senses!

Different representations!

$\mathbf{a} = \mathbf{F}/m$

$\mathbf{a} = d^2\mathbf{r}/dt^2$

ACCELERATION



A body remains in a state of

REST

or

UNIFORM

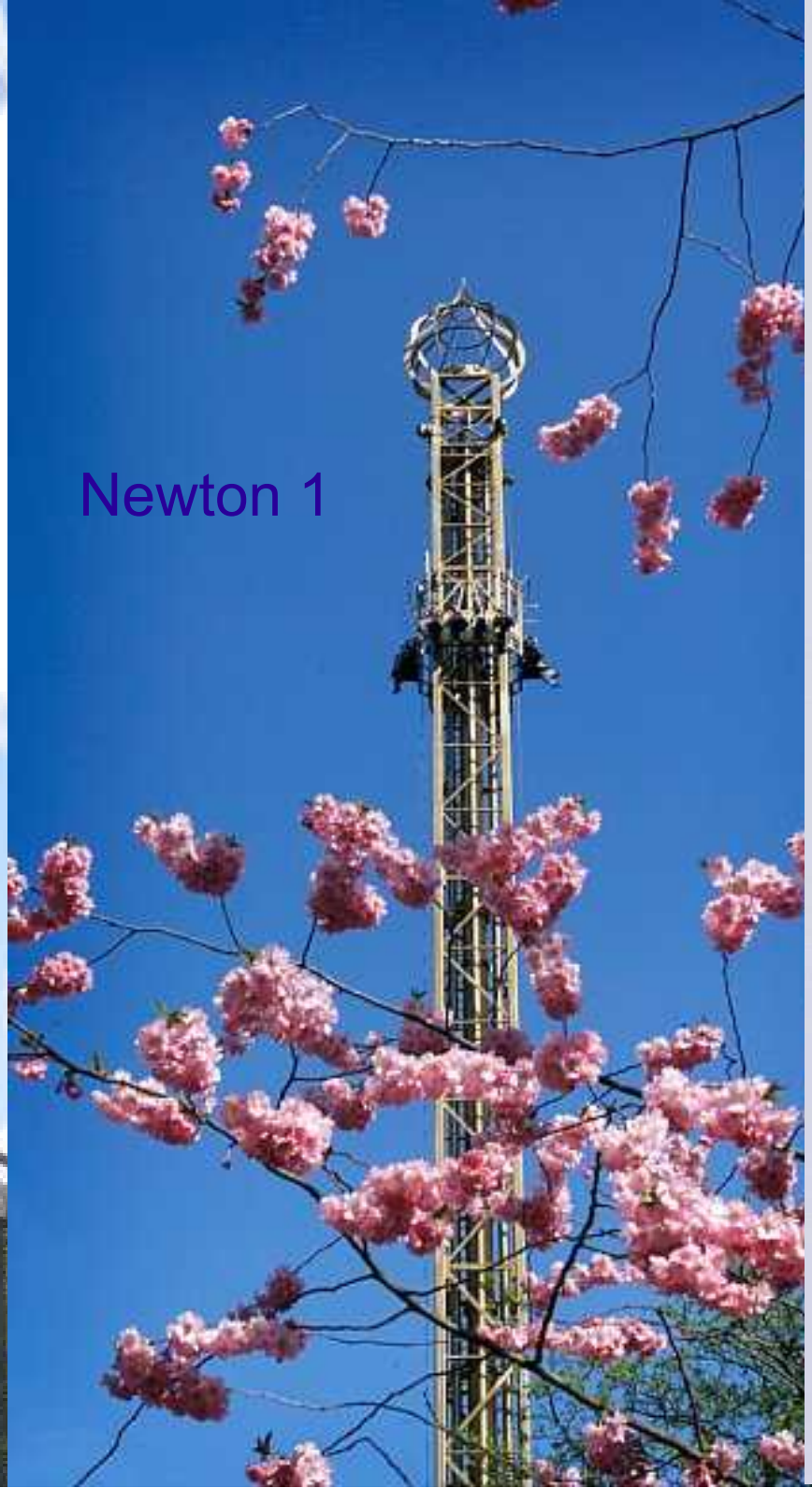
RECTILINEAR

MOTION

Unless affected by a force ..

Newton's first law

Galileo


Newton 1

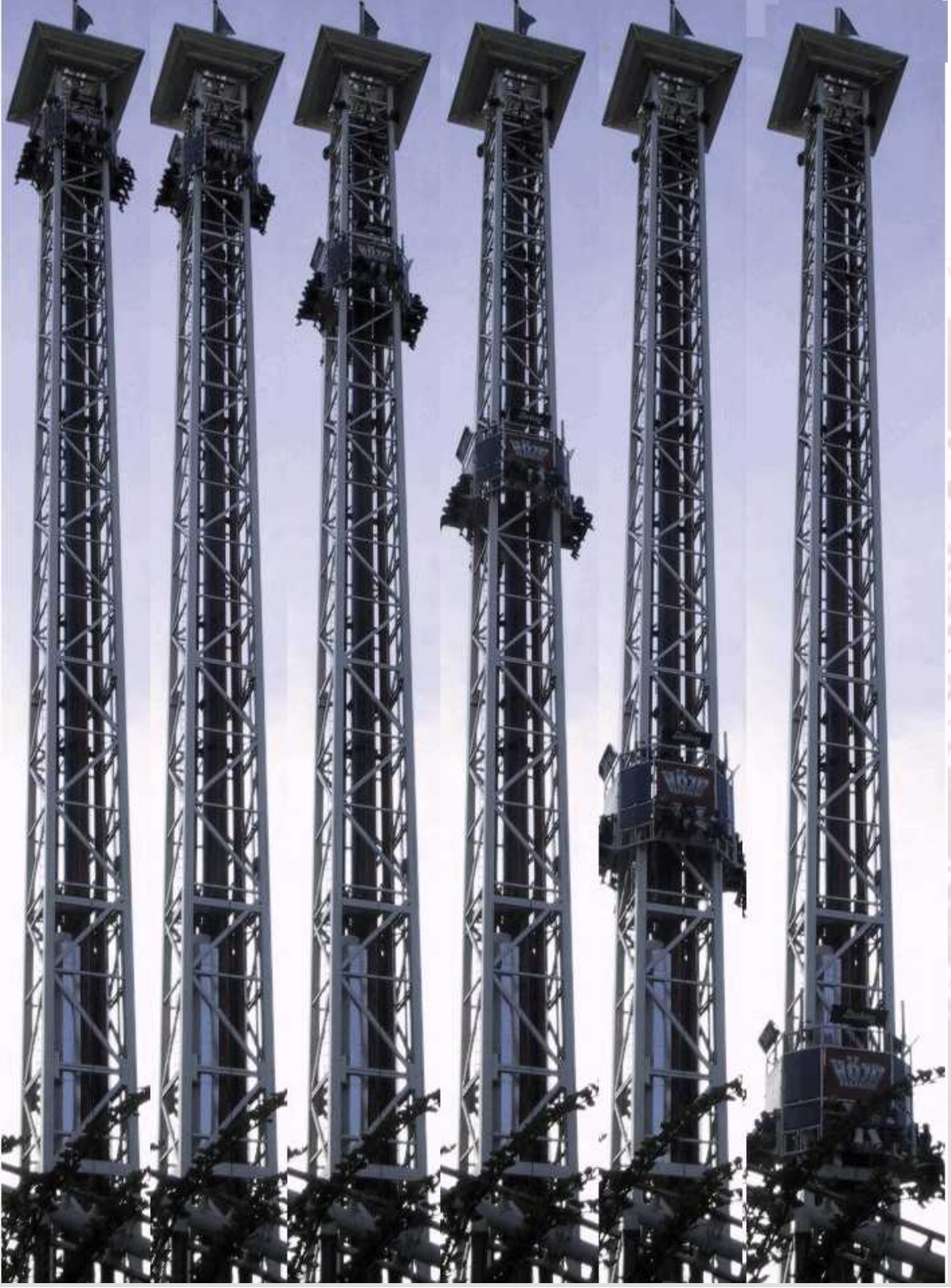
Waiting for the …

ACCELERATION

Newtons 2nd law!

$\mathbf{F} = m\,\mathbf{a}$

Acceleration is experienced throughout the body!
(You don't feel velocity)

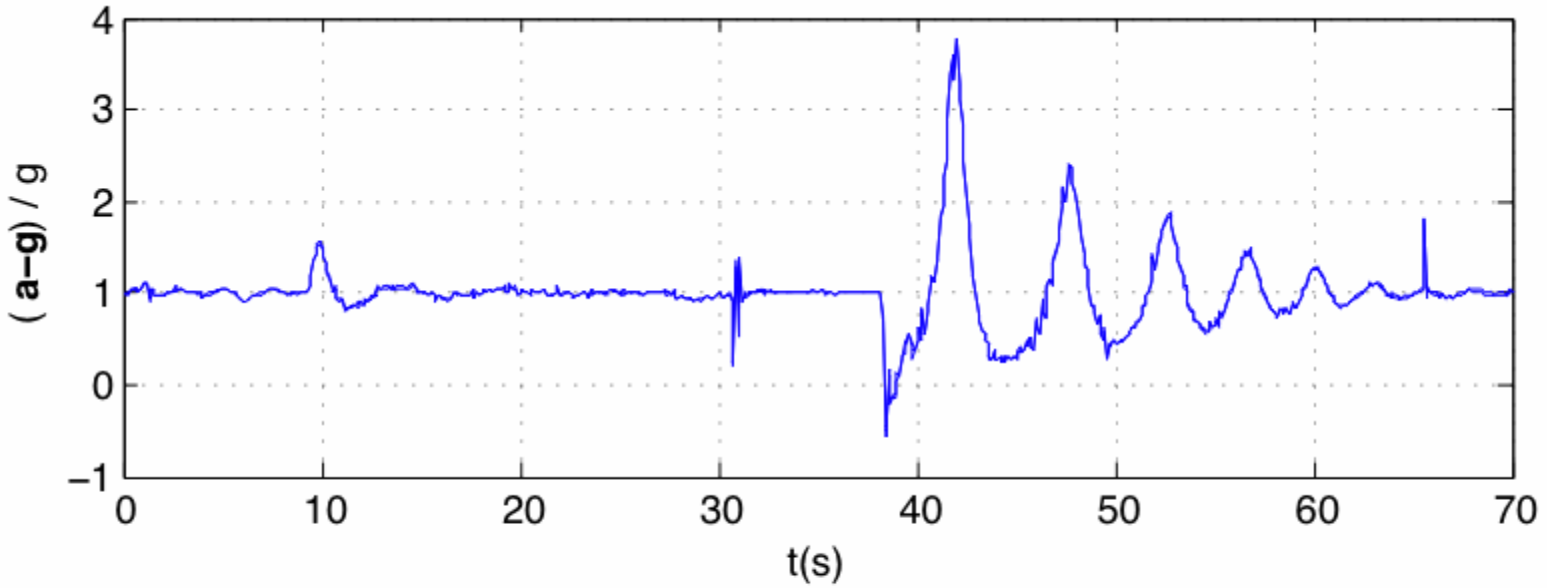


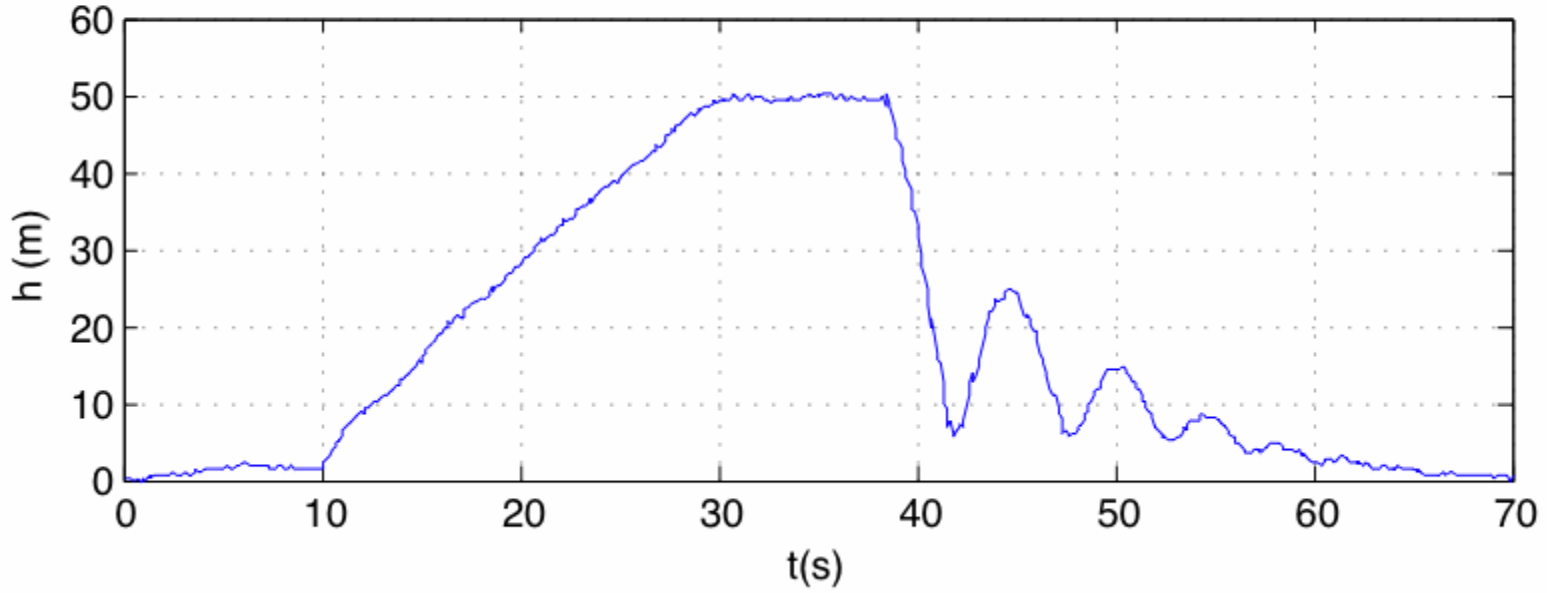
Images of acceleration

...

Where is the acceleration largest during the “Turbo Drop”?

TURBO DROP DATA

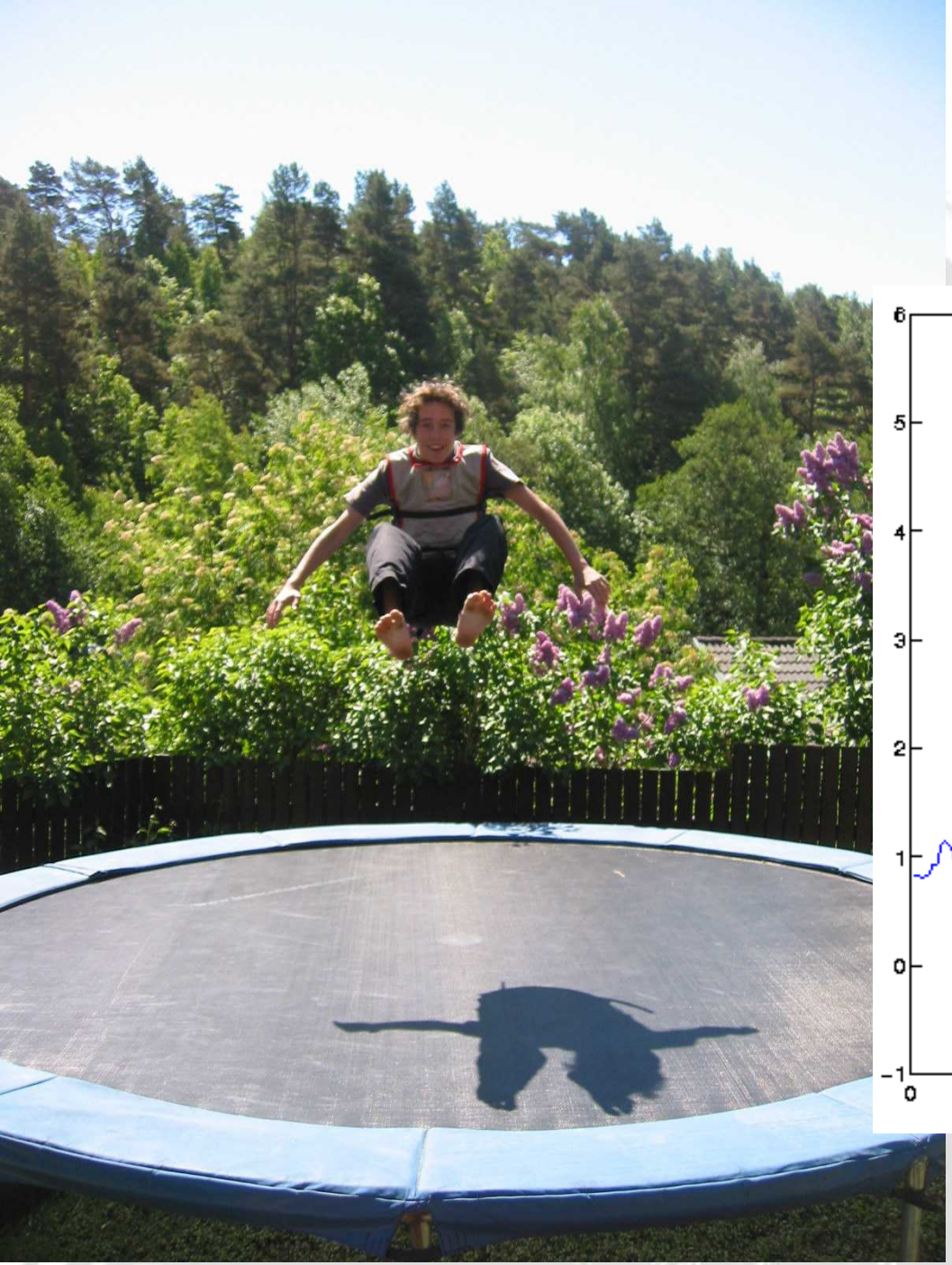


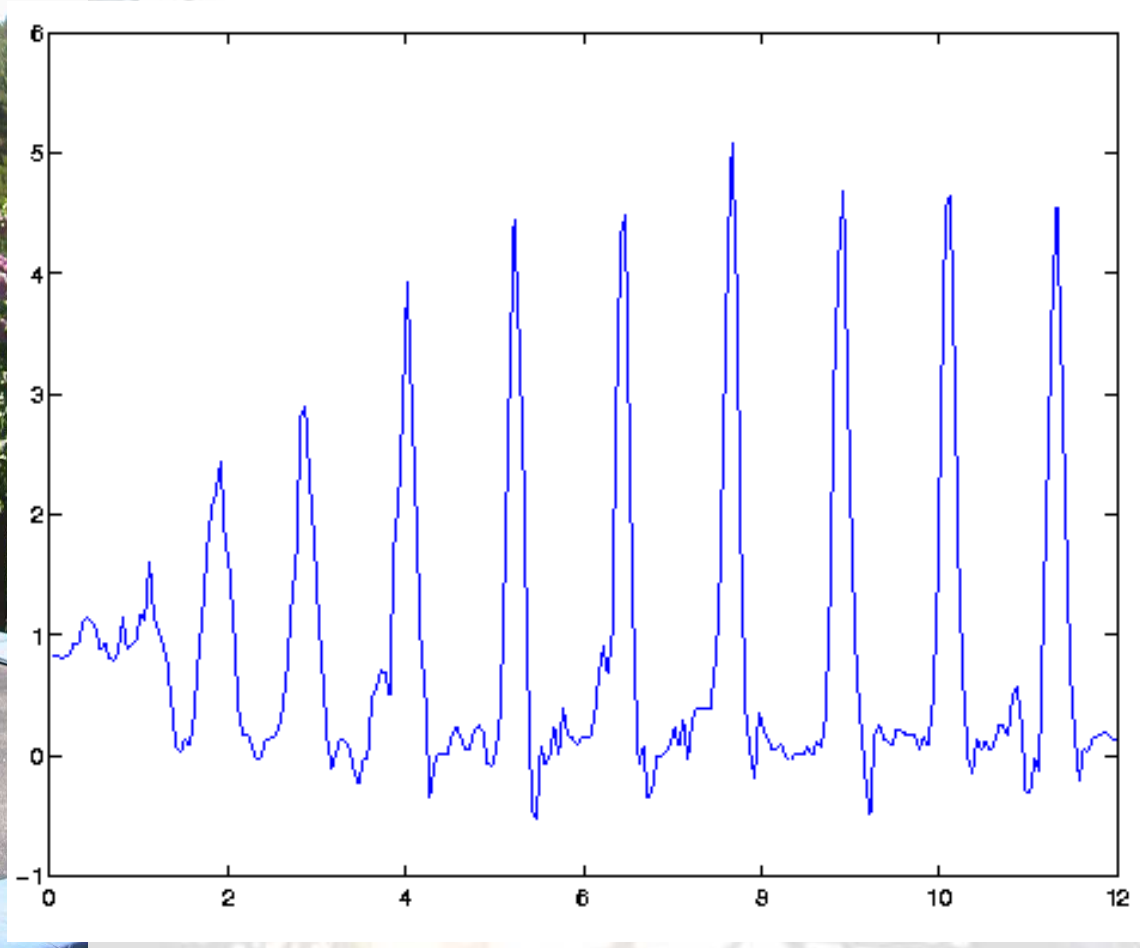


Data collection and analysis (Free fall tower)

Measuring “g-force”

Trampoline



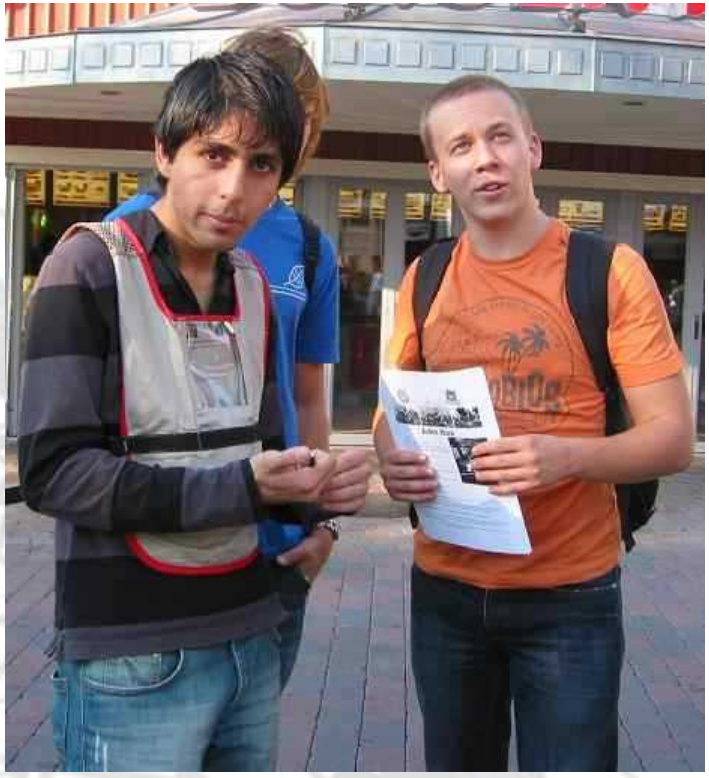


Accelerometer data

Trampolining
Rosannagh
Mac Lennan

https://youtu.be/vm3HAM1czb0?t=1115

Do they learn anything?



"The one who learns most about a subject is the one who talks about it ... usually the teacher" (or IBSE)

+

"Variation theory" (Marton): Experience a phenomenon in qualitatively different ways .... transferrable knowledge

10-year olds
3 months after visit:

When you used the slinky in the Frog Hopper, you got to see how much you weighed.

When you went up, it was stretched out because there was so much speed.

The slinky went up and down. When you were at the highest point, the slinky was the shortest, which means that you were the lightest.

Multiple senses

The Amusement Park as a Science Center

Gender-neutral high-tech!

Physics for many senses, in a variation of contexts, and authentic, enjoyable settings

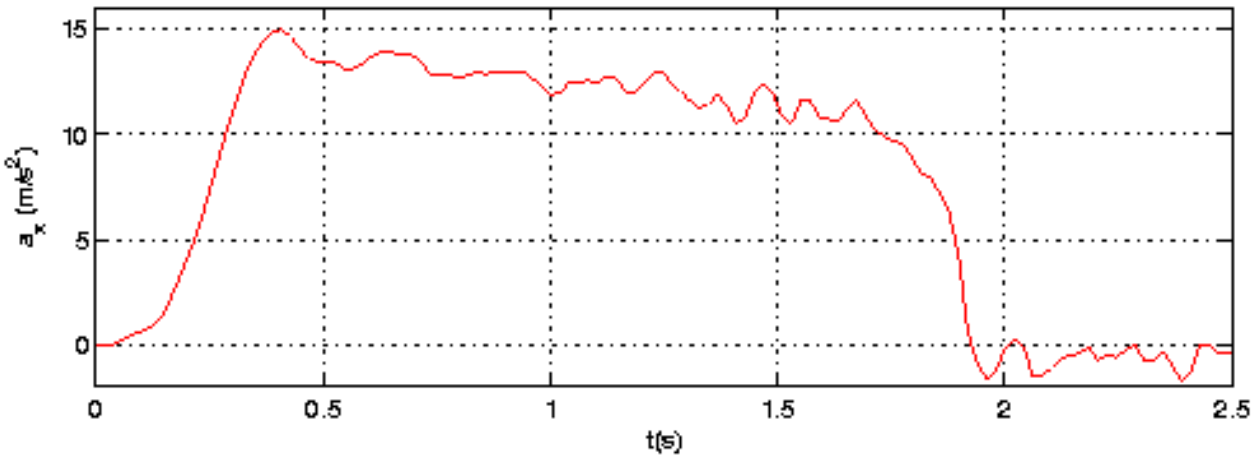
Combining the math and physics with the experience of eyes and your own body,

...and with measurements using toys, mobile phones and electronics

Teacher role: Preparations and follow up are essential

Acceleration -
in everyday language:
Increase of speed
(per second)

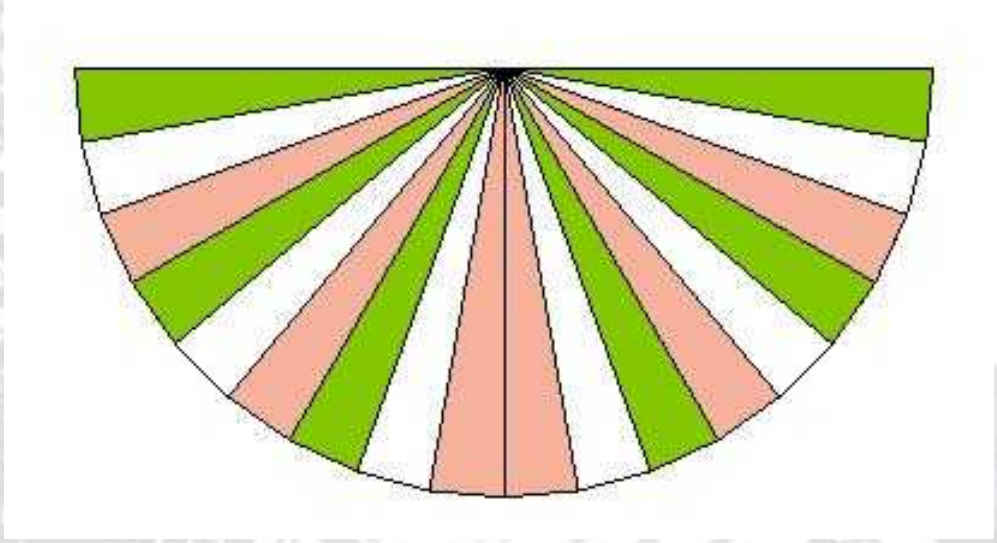
Hydraulic launch



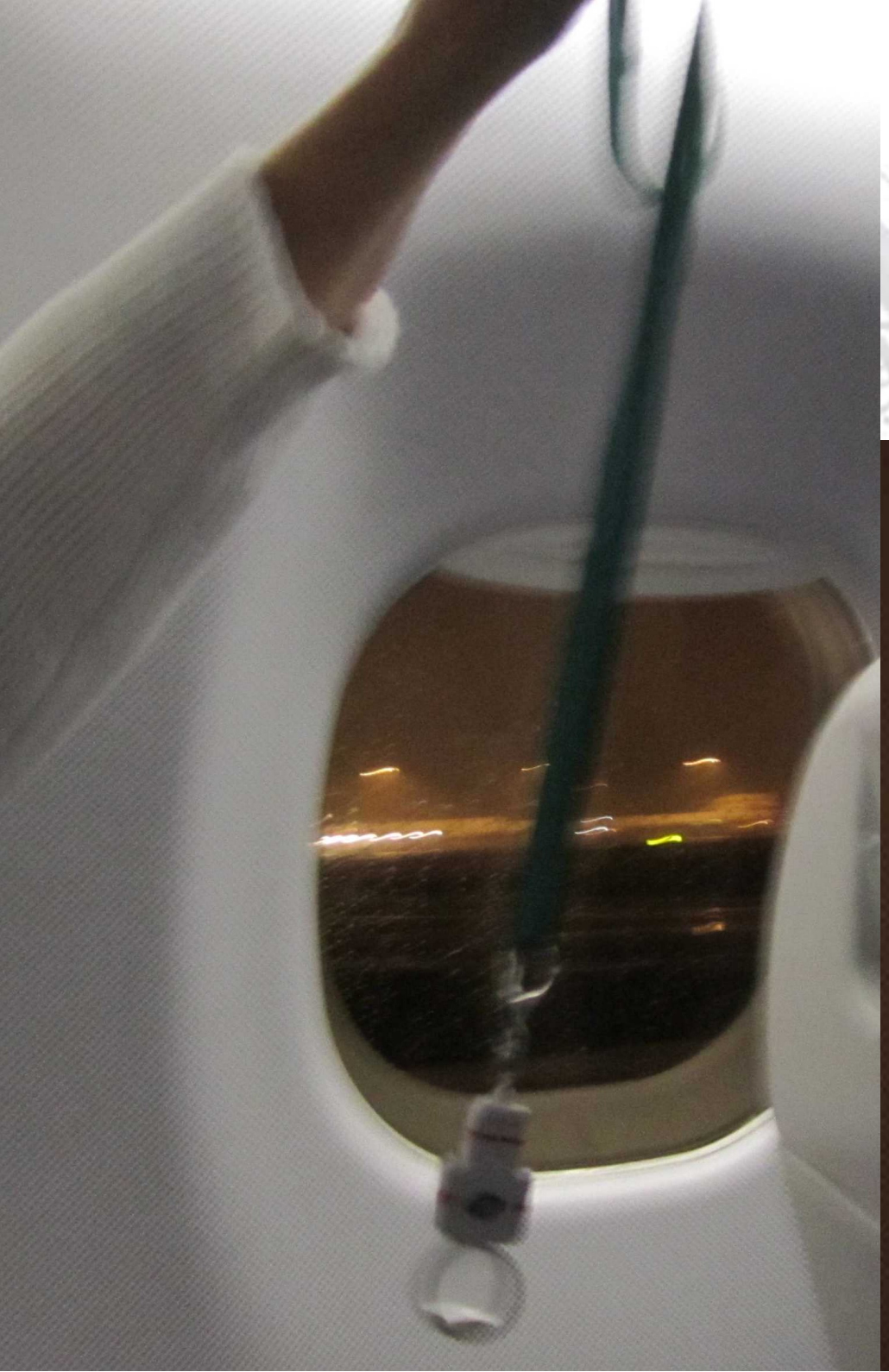
Acceleration - horizontal

- A FORCE is required to change the velocity (speed and/or direction of motion)
- Horizontal acceleration can be measured with a soft toy on a string
- The angle of the string depends on the acceleration

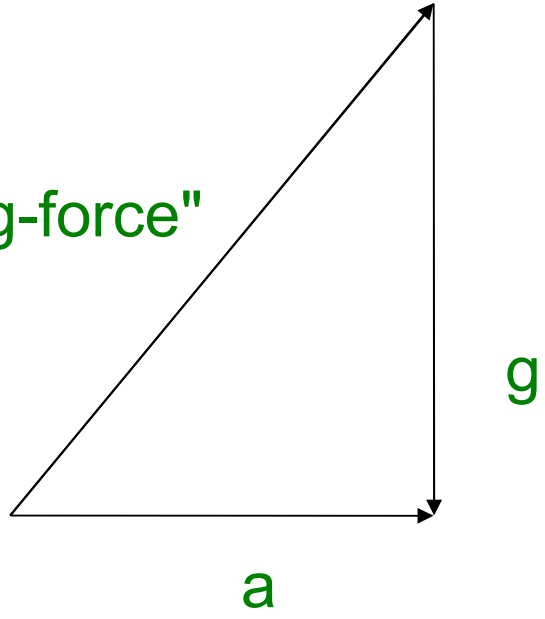
Example: 10 degrees –
from 0 to 50 km/h in 8s

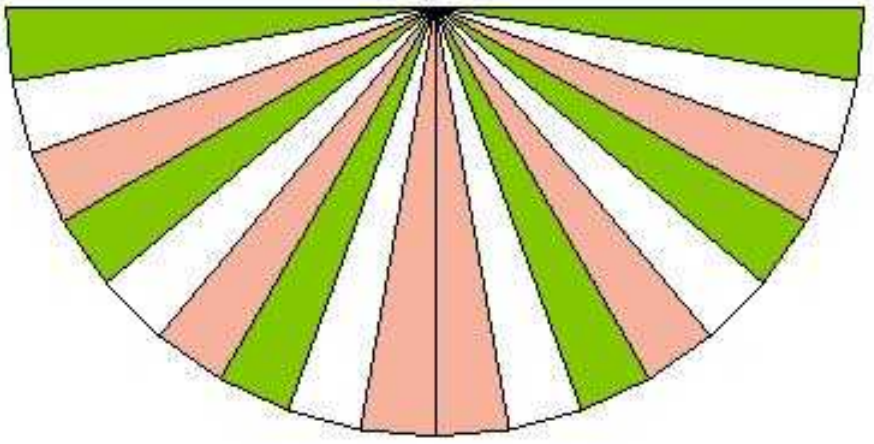


Start and landing of an airplane



Measuring acceleration – and g-force (In horizontal motion)





g – acceleration of gravity - downwards
a – centripetal acceleration – to the center
”g-force”:force (per kg) acting on the body

How large acceleration?

The angle is about 45° corresponding to an acceleration of g.

Acceleration -

- Everyday language?
- In the physics textbook?
- Different types of acceleration?
- Experiencing?
- Measuring?

Velocity
Acceleration
Rotation

Photos by
Howard Schatz

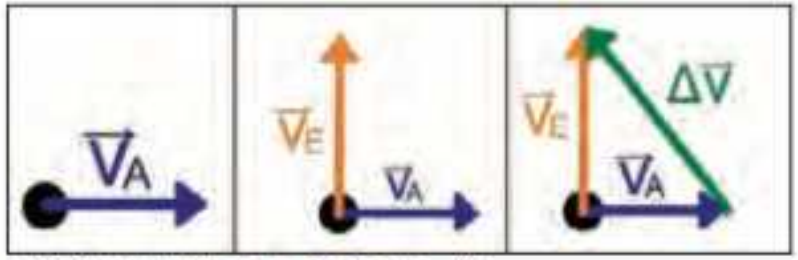
Luke Donald (Motion Study #1042)

http://www.howardschatz.com/newsite/portfolio/images/action1/014.jpg

3.11 Geschwindigkeitspfeile im Stroboskopbild des Spielzeugfliegers

2.12 Geschwindigkeitspfeile im Stroboskopbild des Fußballes

Einführung in die Mechanik



4.13 Konstruktion des Pfeils von $\Delta\vec{v}$

Martin Hopf et al

Amusement rides in textbooks?

- Free fall in drop towers
- Centripetal forces in carousels
- Potential and kinetic energy in roller coasters

Different themes, designs and locations - same physics

Acceleration?

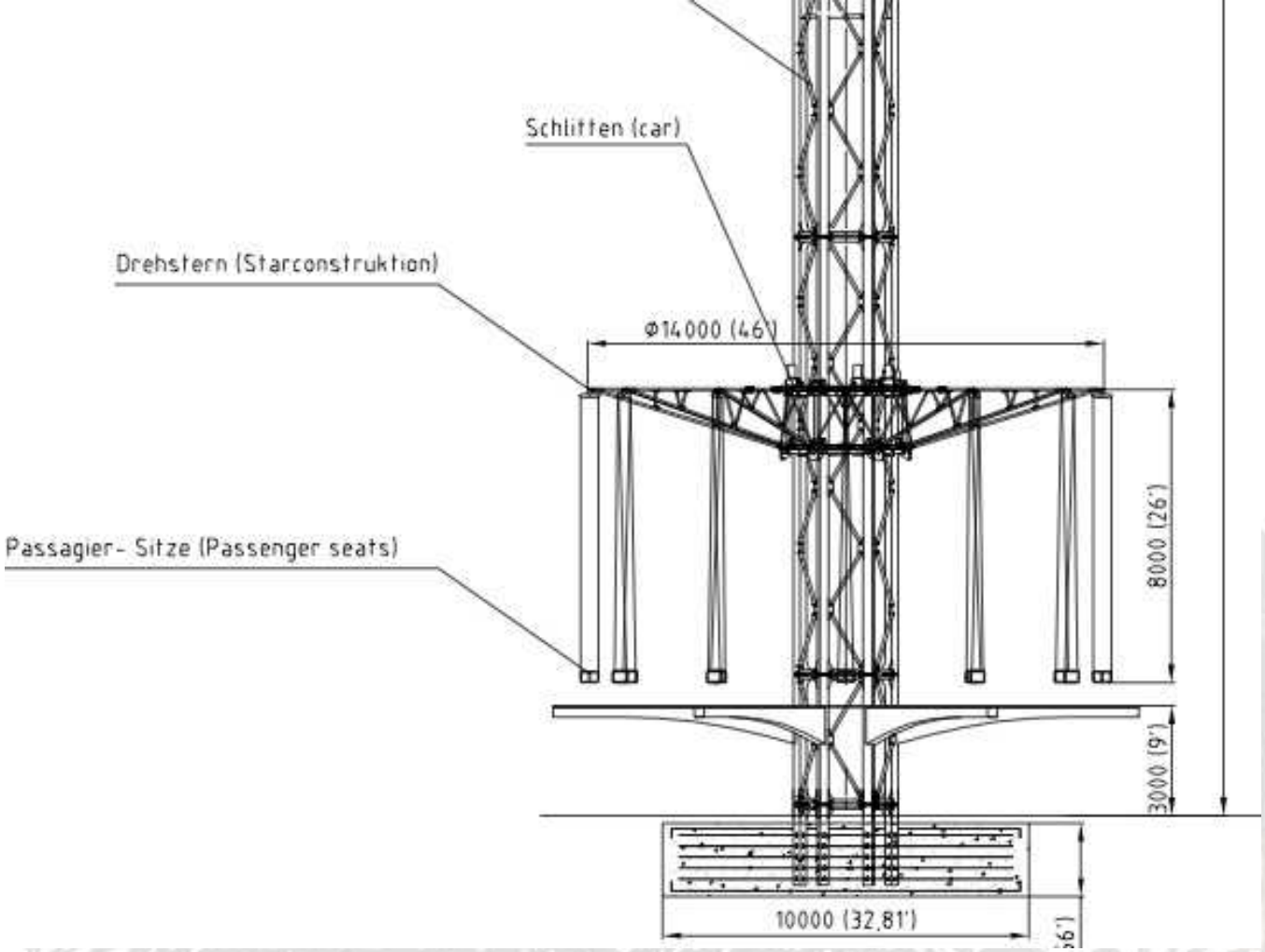
Luftikus, 21 Feb 2016

STARFLYERS

Himmelskibet
Copenhagen

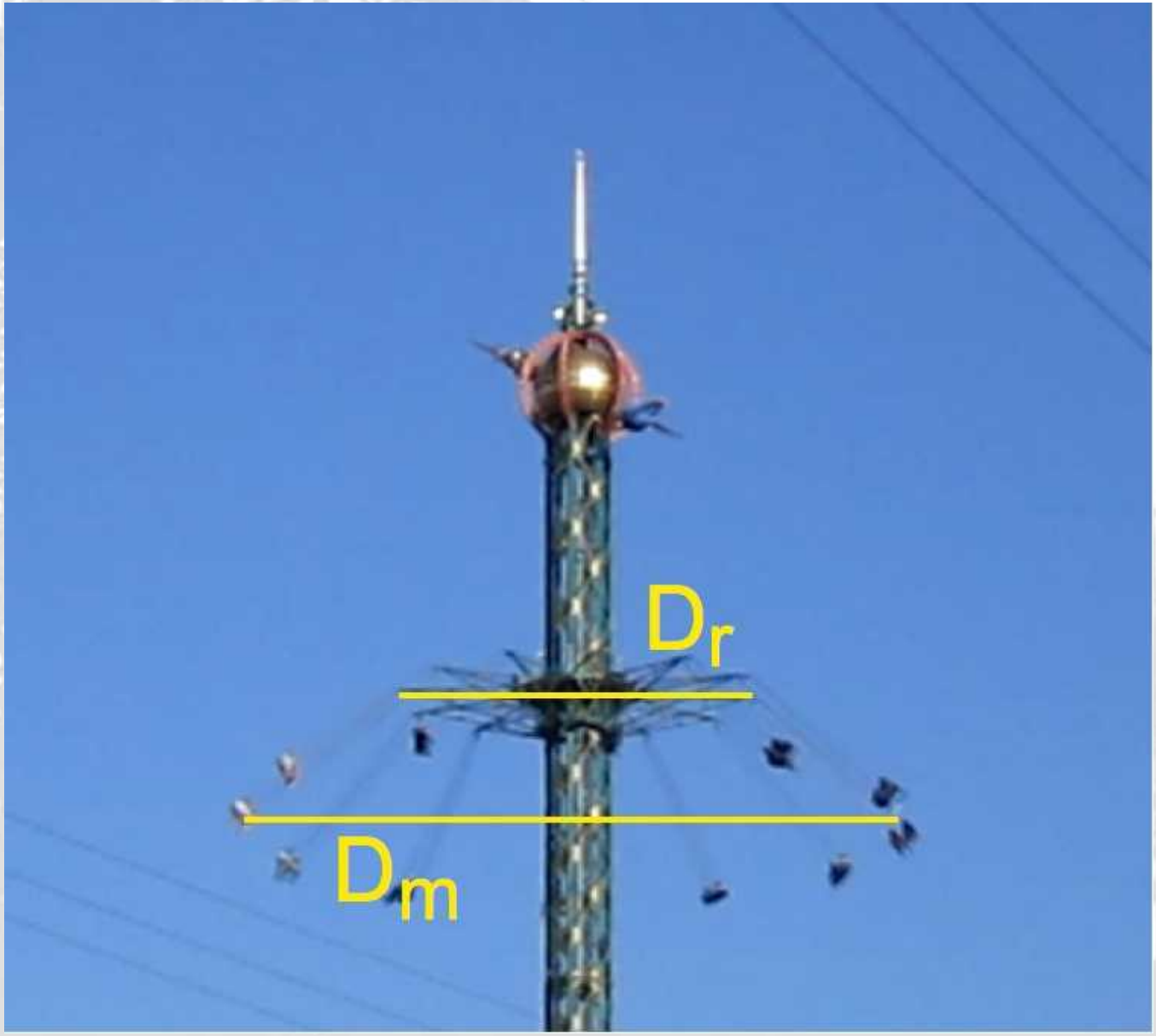
Eclipse
Stockholm

PraterTurm
Wien

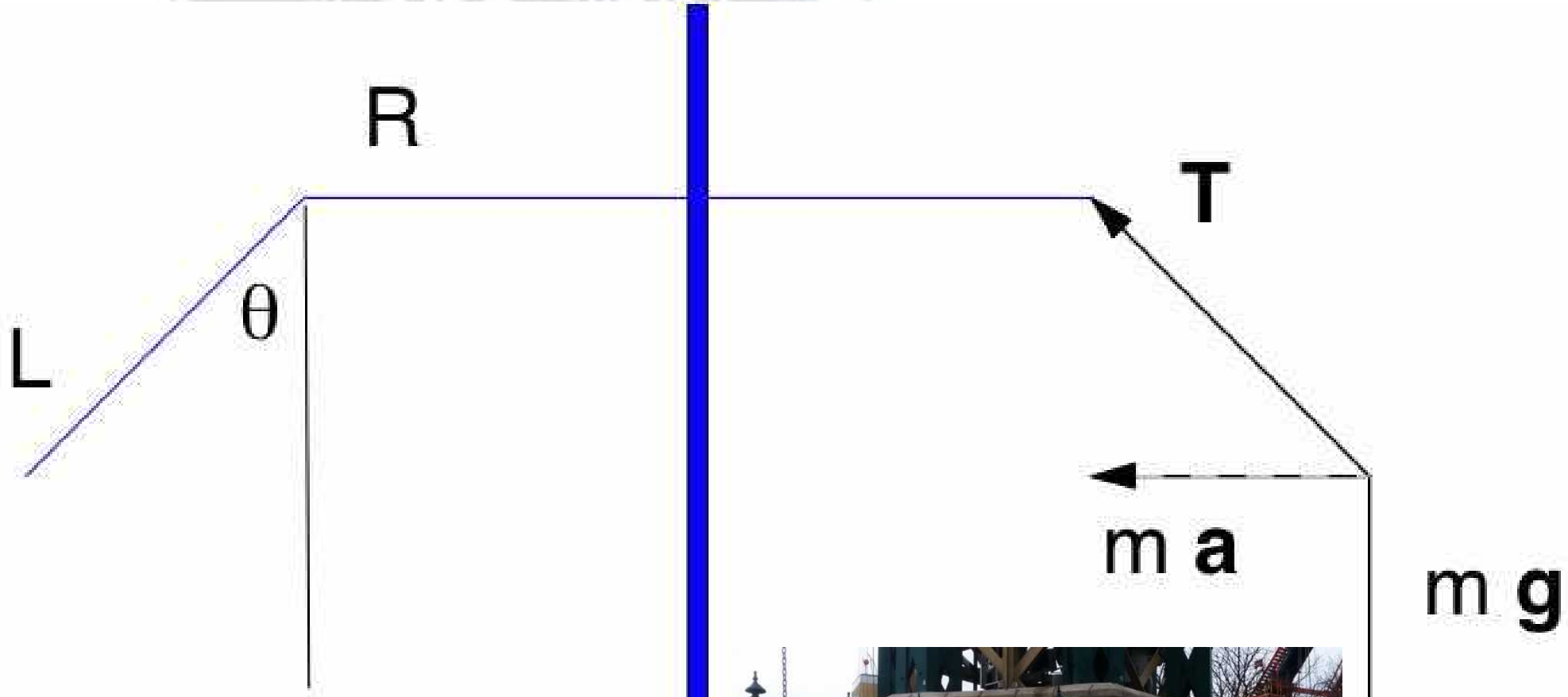

Schlitten (car)
Drehstern (Starconstruktion)
Ø14000 (46')
Passagier- Sitze (Passenger seats)
8000 (26')
3000 (9')
10000 (32,81')


Pixie Town

Relation T and angle?



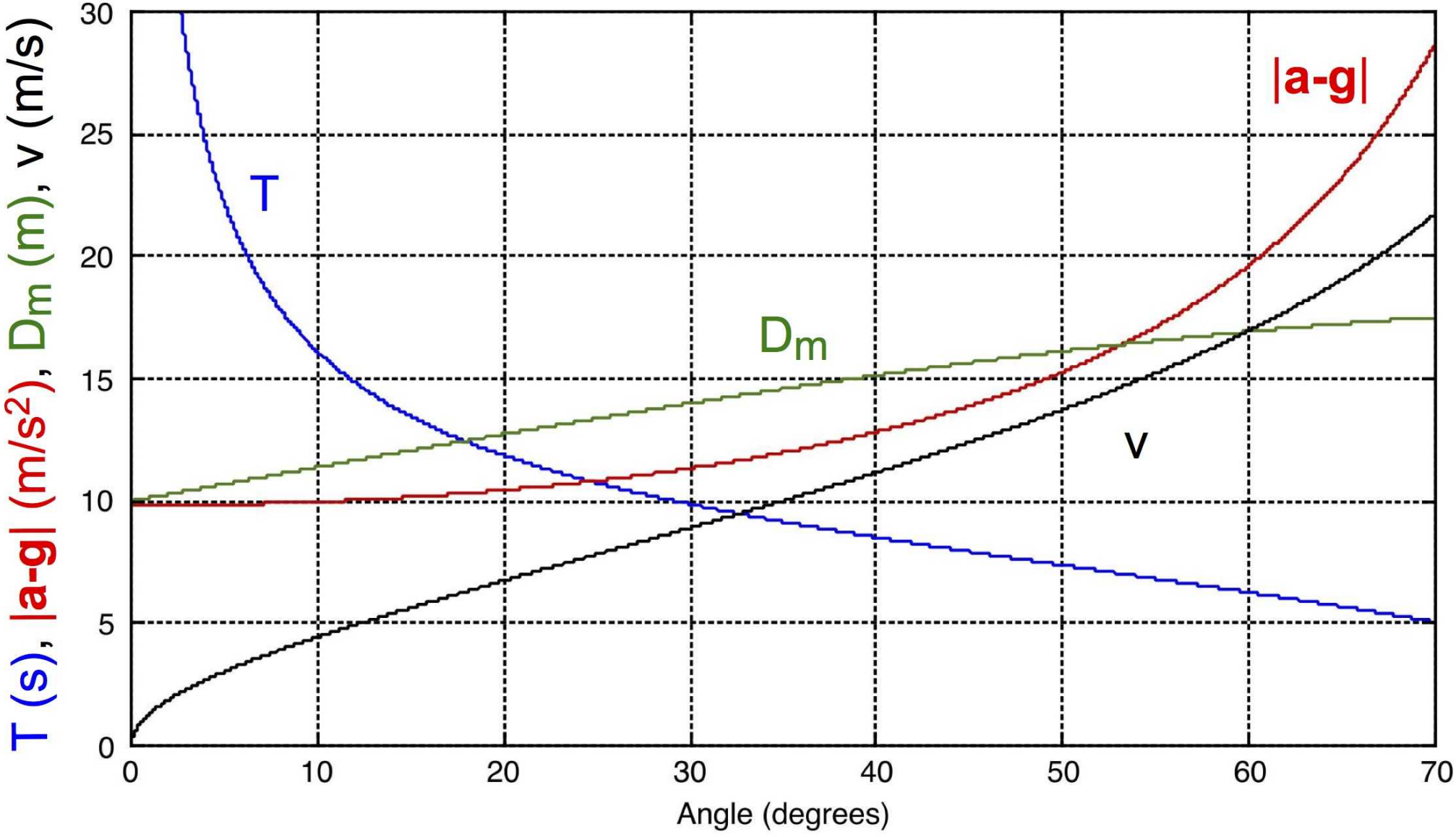
Forces in a “Kettenflieger”



(Wellenflieger film)

PraterTurm: D=14m, L=8m

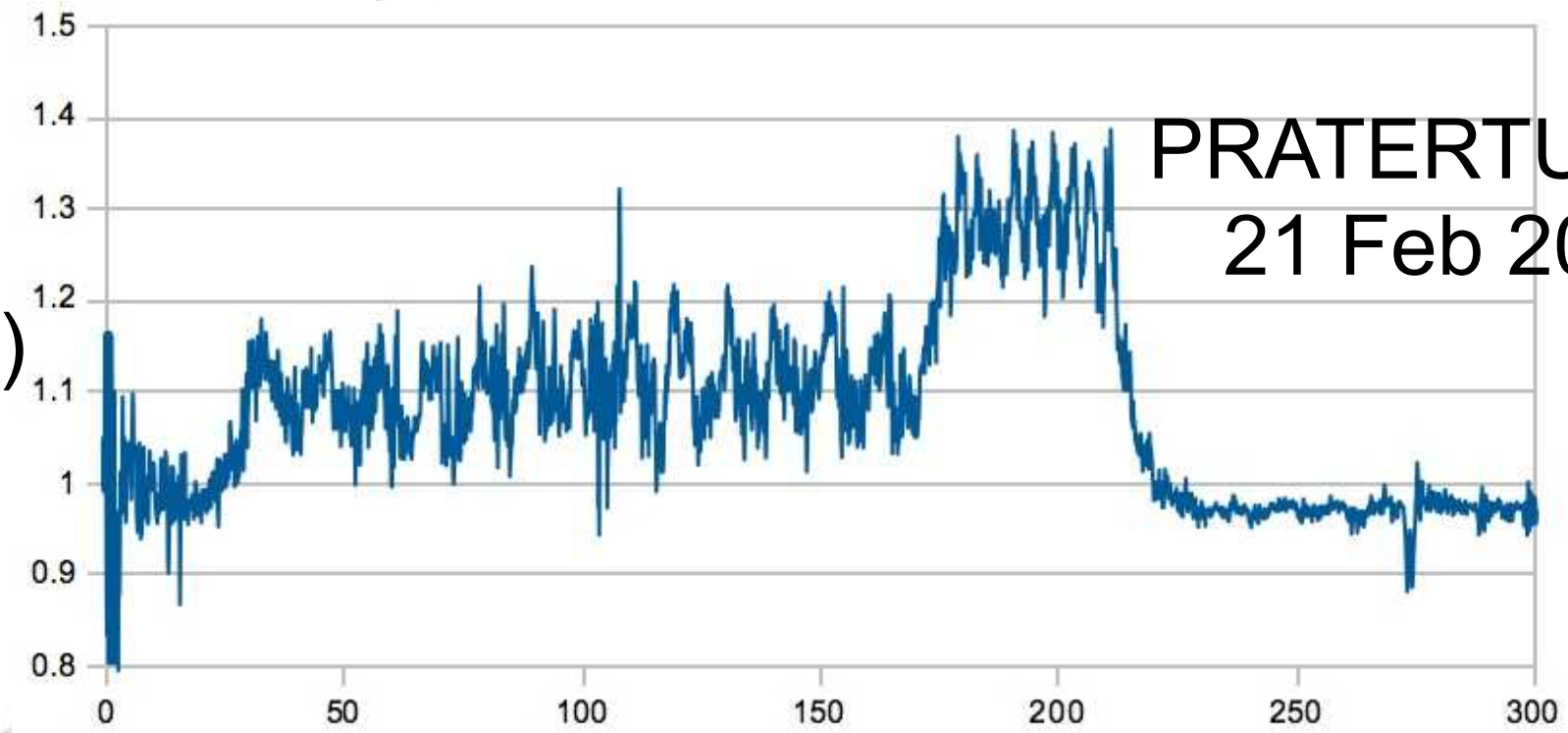
(and Himmelskibet, Tivoli, Kbh)



PRATERTURM
21 Feb 2016

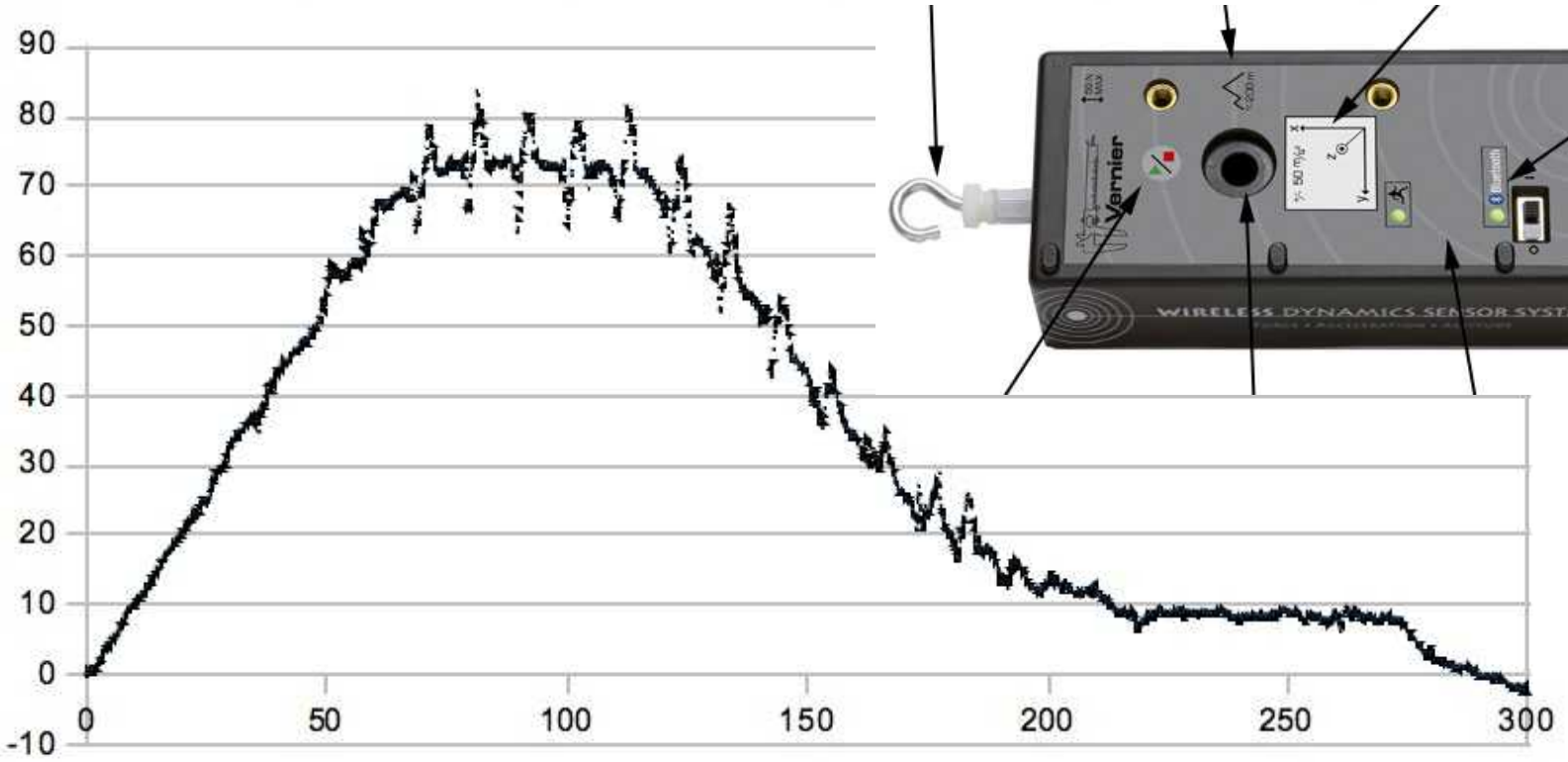
"g"

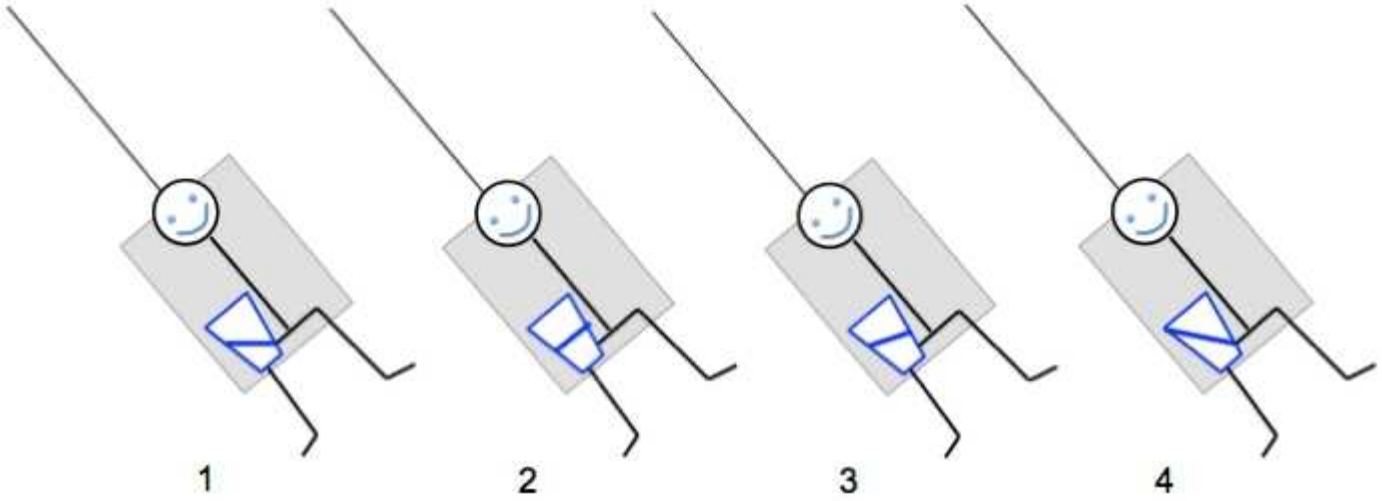
(X/mg)



h (m)

(from Pressure Strong wind ...)




1
2
3
4

With water in a Wellenflieger

(from film
by Håkan Kjällqvist)

Do all swings hang in the same angle?

(Film)

VOLUME 49 NUMBER 4 JULY 2014 ISSN 0031-9120

Physics education

iopscience.org/physed

When mass does not affect motion

The equivalence principle explored

Papers: Wobbly strings, Sensitive foils **Frontline:** Determining tension

IOP Publishing

http://tivoli.fysik.org/english/articles/

Amusement rides offer illustrations of physics principles that are known to be difficult!

- Newtons's laws apply also to HUMAN bodies
- Equivalence principle: Inertial (ma) and Gravitational (mg) mass
- Acceleration and rotations are absolute - can be measured within the system.

a = F /m

Acceleration is felt throughout the body!

Challenges ?

- Field trip … practical considerations
  - Schedule
  - Transport
  - Money
  - Permits
  - Equipment

- Safety
  - Normally not permitted to bring anything on rides
    CONTACT PARK BEFORE!
- Physics and Assignments

Teacher roles in an amusement park

- Absent
- Time keeper
- Bag guard
- Observer / co-participant
- Equipment / computer centre
- Instructor

How can teachers make use of amusement rides for STEM education?

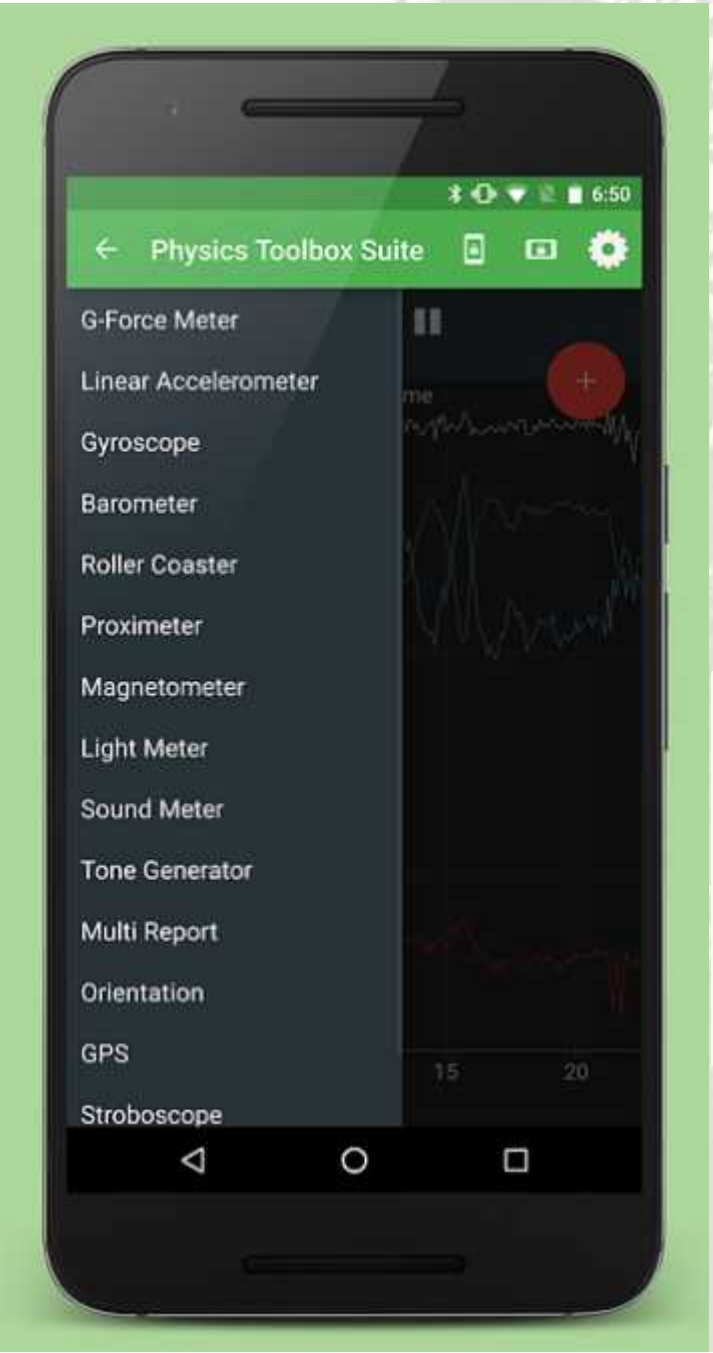
- Common shared experience + use authentic data, photos, movies in examples
- Visits: Different levels of difficulty
  - Quiz + identify accelerometer graphs
  - Joint focus on 2-3 familiar rides
  - Group assignments, 2-3 rides/4-6 students
  - ... with electronic data collection
  - Take part in science day - or visit on your own
- Preparation - follow-up (+ pre-post diagnoses)

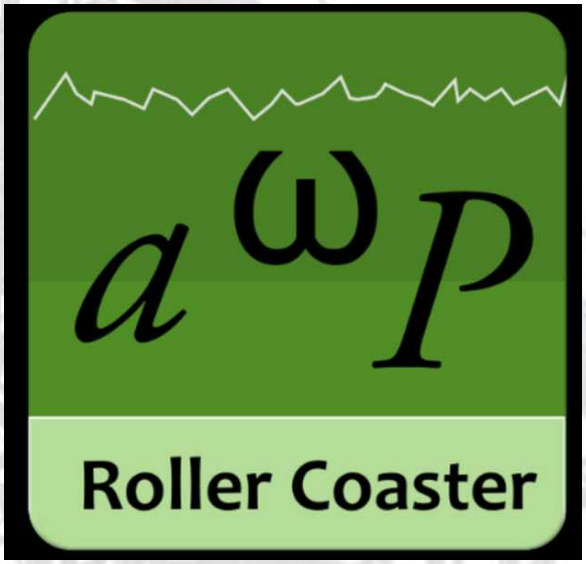
Playgrounds provide useful practice!!!

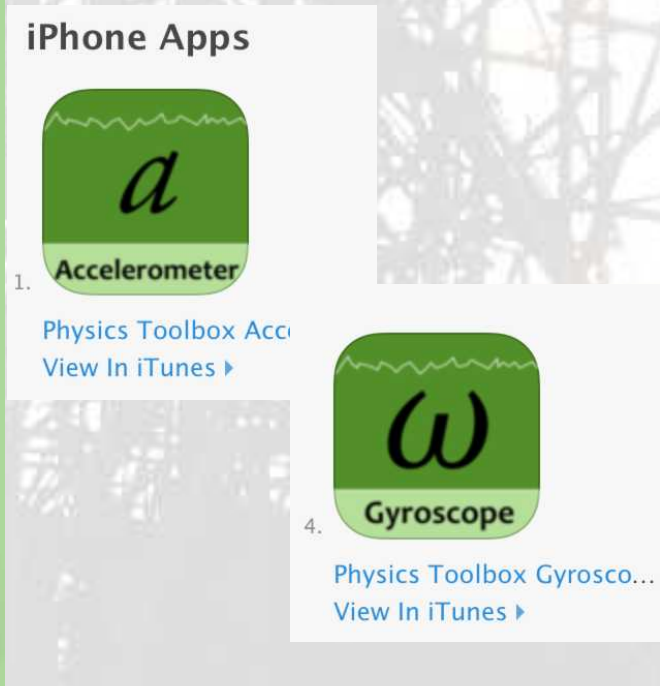
Preparation and follow-up are essential

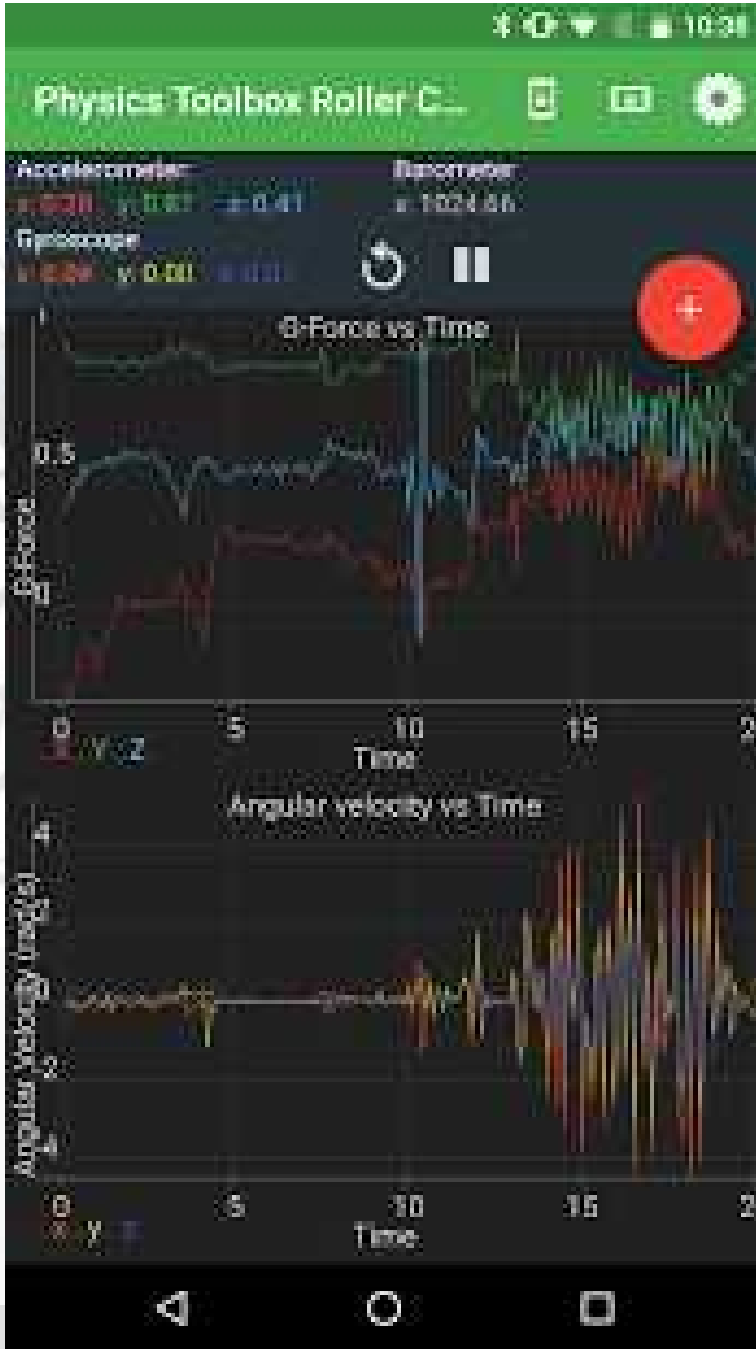
(e.g. Rennie and McClafferty)

Physics Toolbox Suite









How do you measure rotation?

. . . and how do you know that the Earth spins around its axis?

ROTATION IS ABSOLUTE
(not relative)

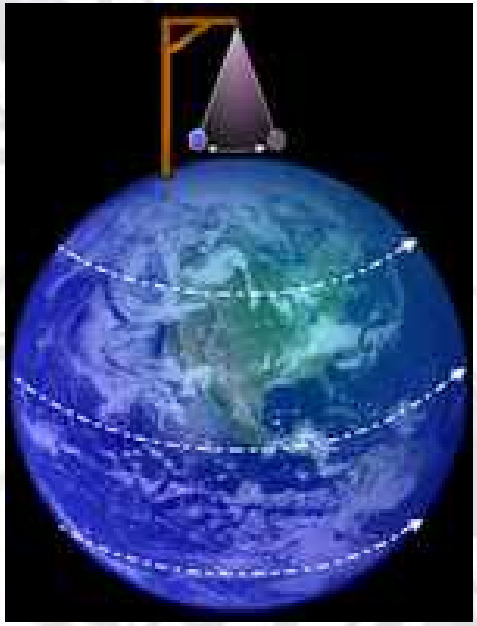
Have you tried throwing a ball in a carousel?

… or tried a water pistol?

(preferrably in a playground carousel)

Or tried to let something swing from string?

How do we know that the Earth spins around its axis?



(How do we know if anything rotates ?)

“"I learned that when going in the Pony Carousel, the cuddly toy kept going in the same direction while I was going around."

"I learned that when I went on the carousel, the toy continued in the same direction, while I moved around”

(10-year olds, interviewed 3 months after the visit)

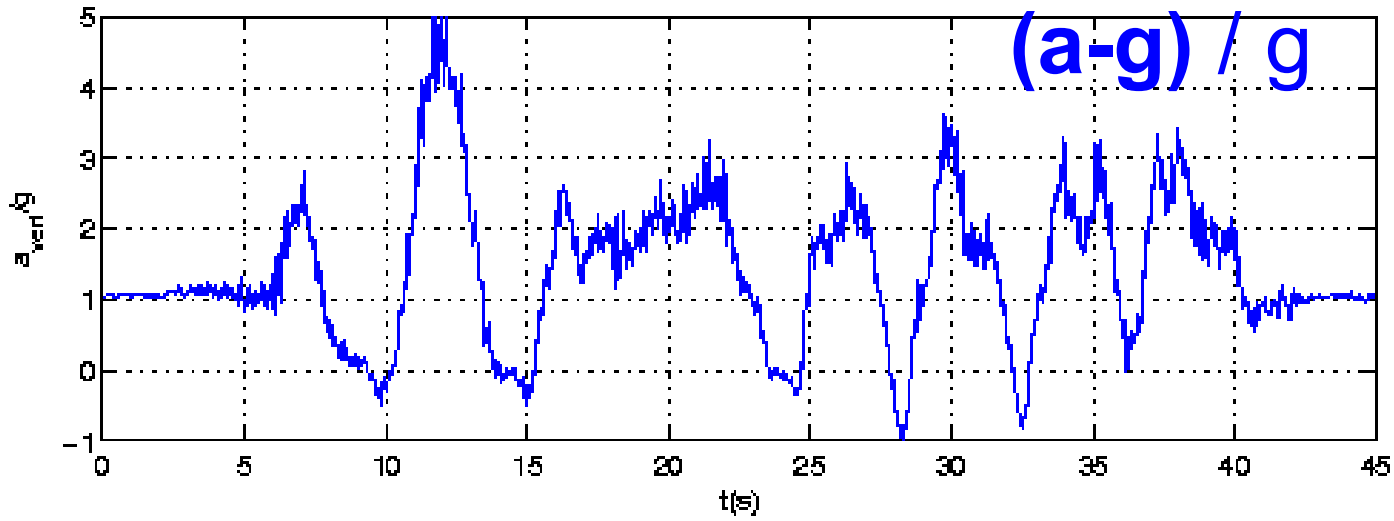
(DO TRY THIS!)"

+ Liseberg

SWINGS:
Energy & $T=2\pi/L$

Energy conversions in roller coasters

Energy principle - Energy conversions



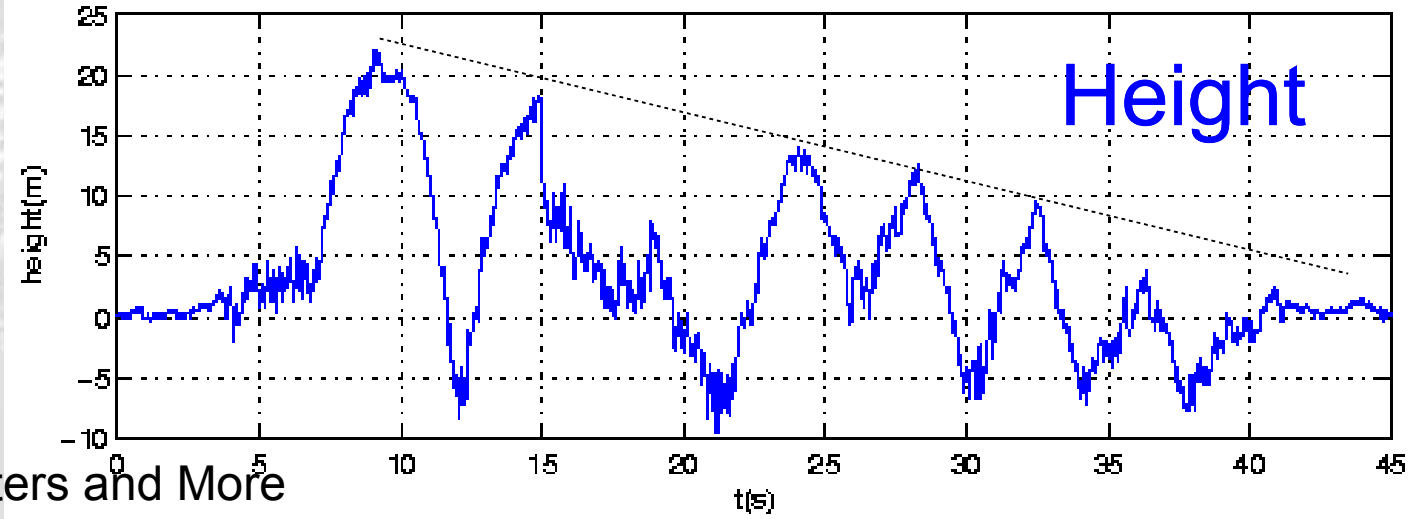


FOTO: Jochen Peschel, Coasters and More

The initial energy from the launch takes the train over the top.
Shape of the loop?

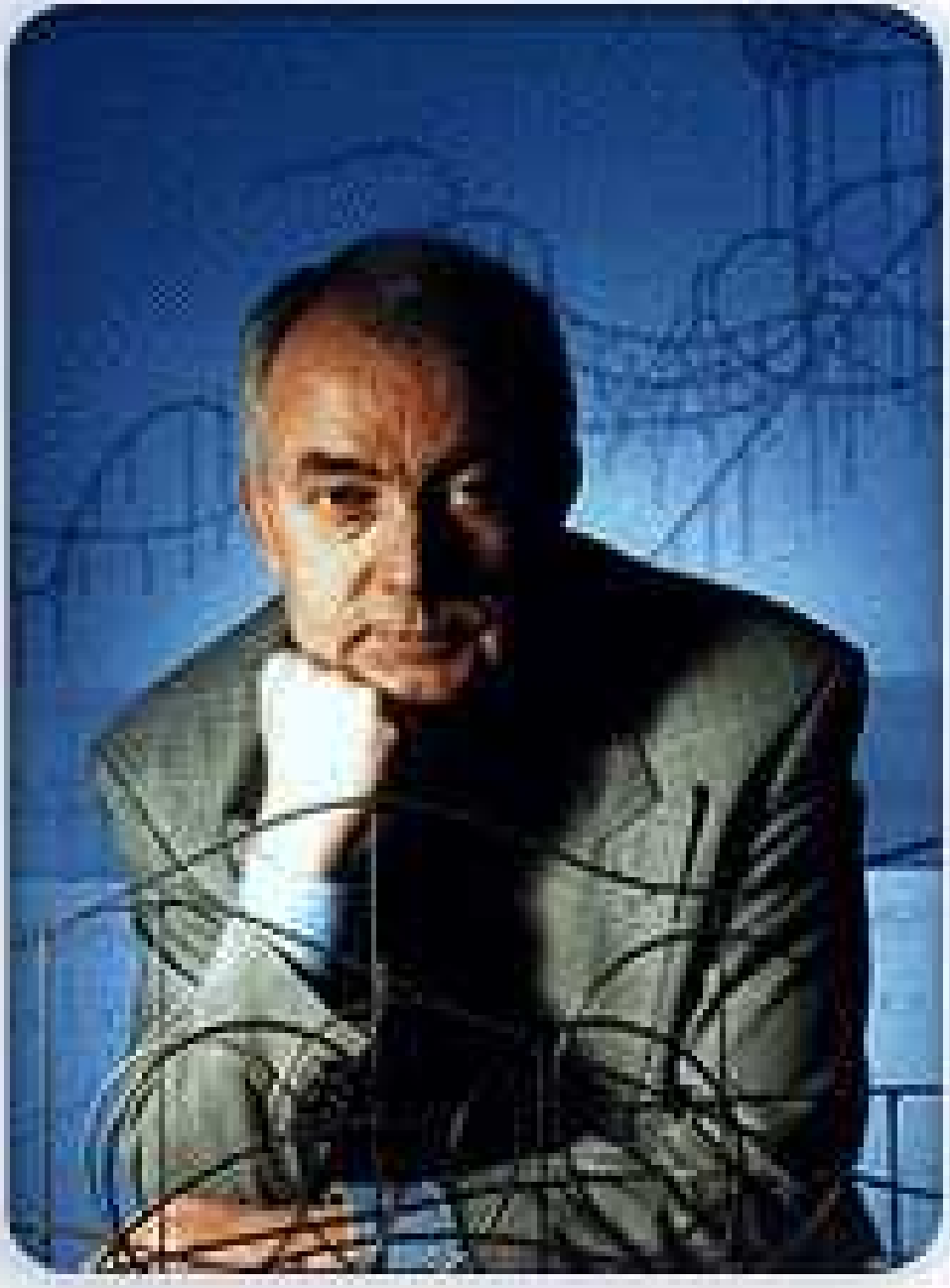
Boomerang

(“normal” and Suspended)

Look at the loop!

Roller coaster loop shapes

Werner Stengel



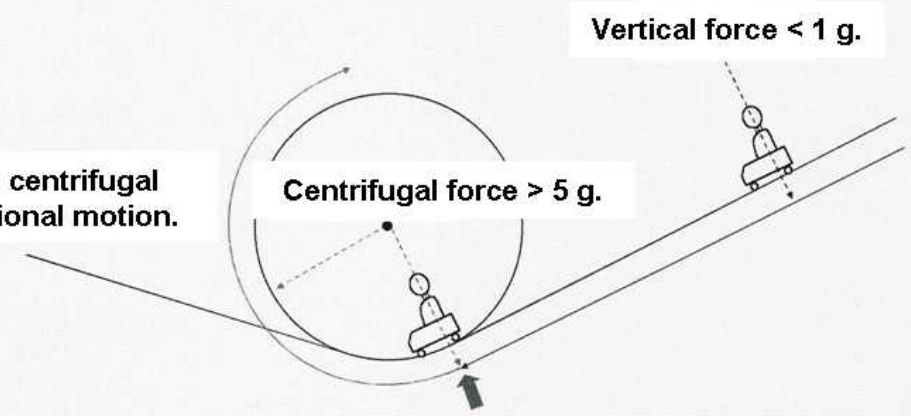
Why the Circular Looping is not Feasible:

With a circular looping two phenomena overlap.

Phenomenon 1

Sprain of the Spine

1) When passing along a straight line only small forces are acting vertical to the track.



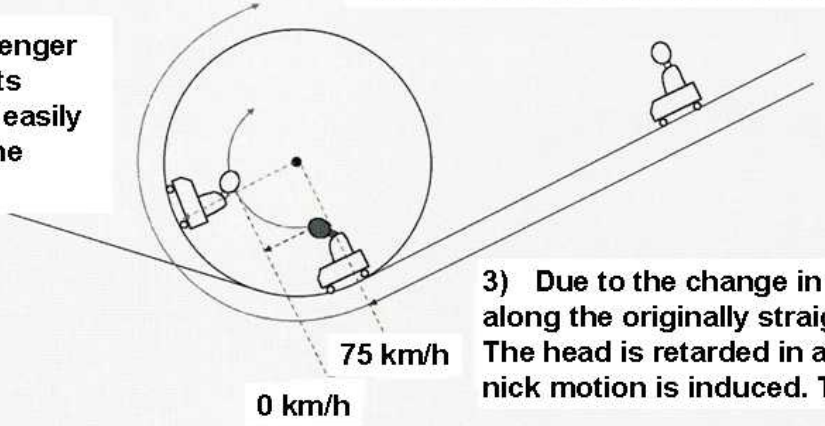
2) When entering the circle high centrifugal forces are acting due to the rotational motion.

3) At the transition point from a straight line to the circular arc an abrupt increase from low to high vertical forces is encountered which leads to a sprain of the spine.

Phenomenon 2

Whiplash injury in the cervix-neck-shoulder area.

1) Running down a hill the passenger approaches the looping. He moves along a straight line.

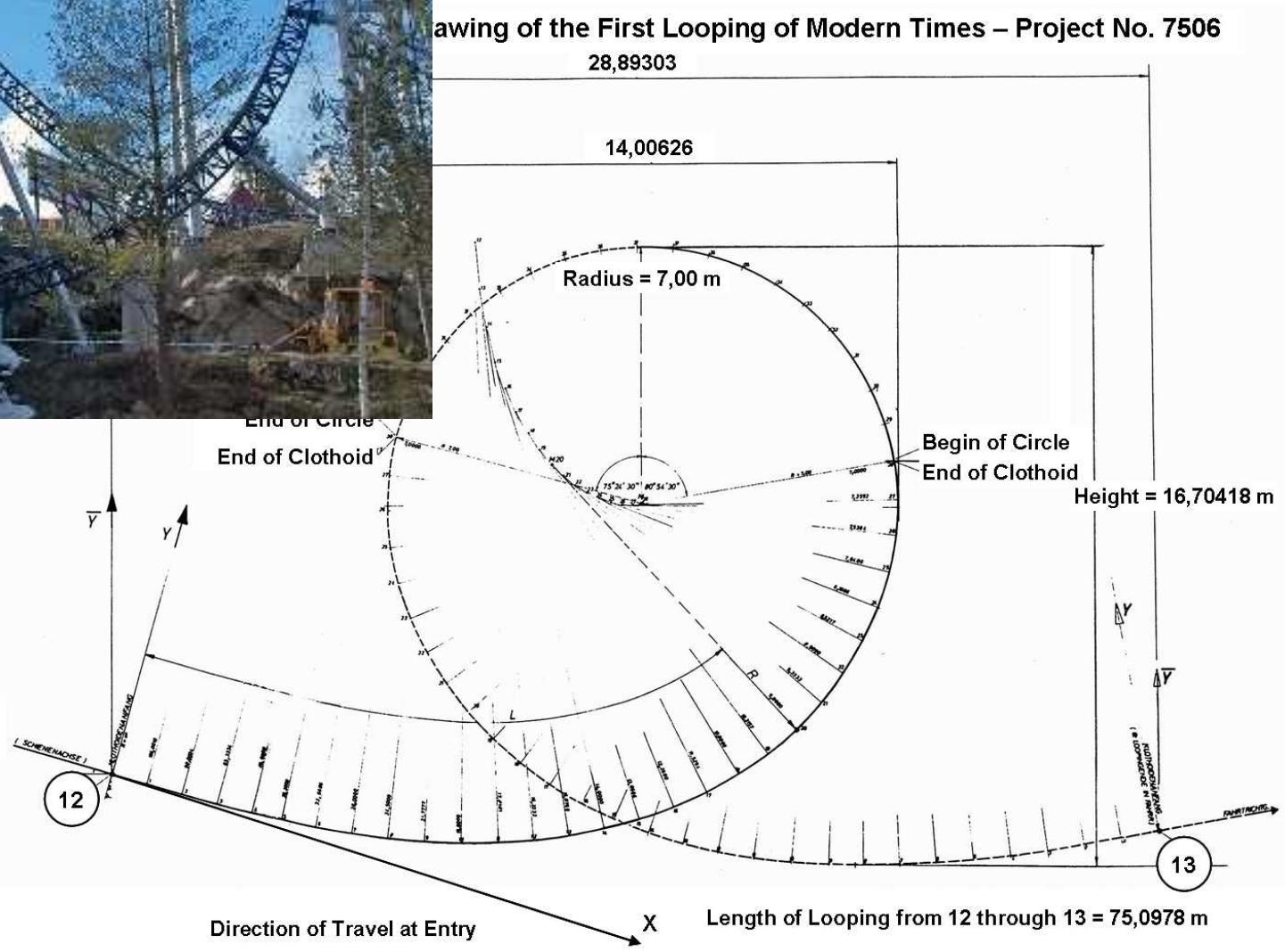


2) When entering the looping the passenger unit is forced to follow a circle. Due to its inertia the passenger's head which can easily move relative to the body still follows the straight motion .

3) Due to the change in the direction of travel the velocity along the originally straight trajectory is reduced to 0 km/h. The head is retarded in a very short time and a sudden violent nick motion is induced. This leads to the whiplash.

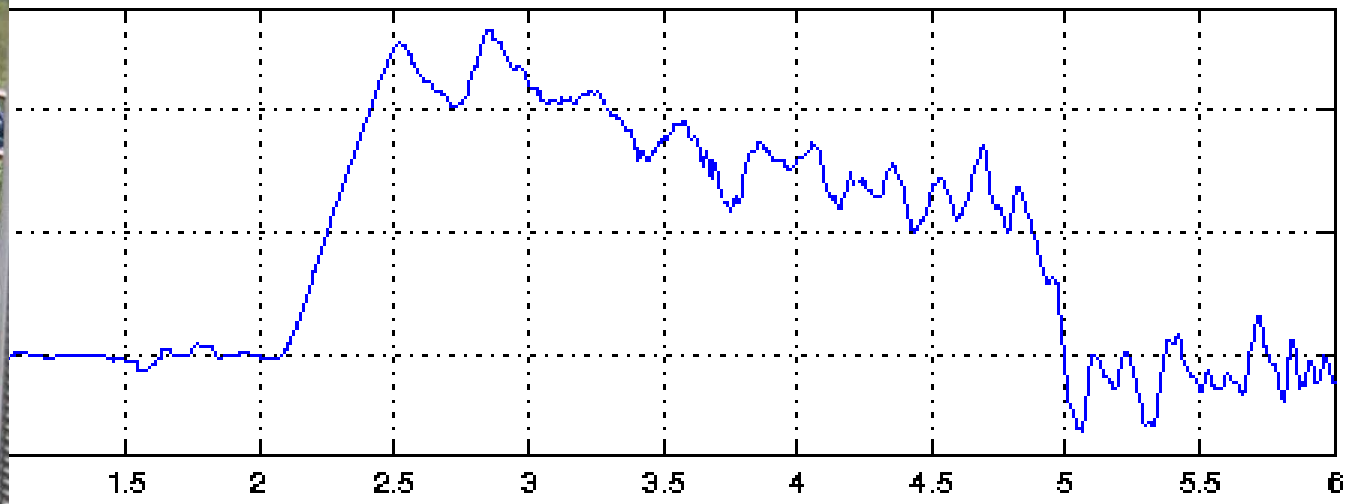
Picture 8

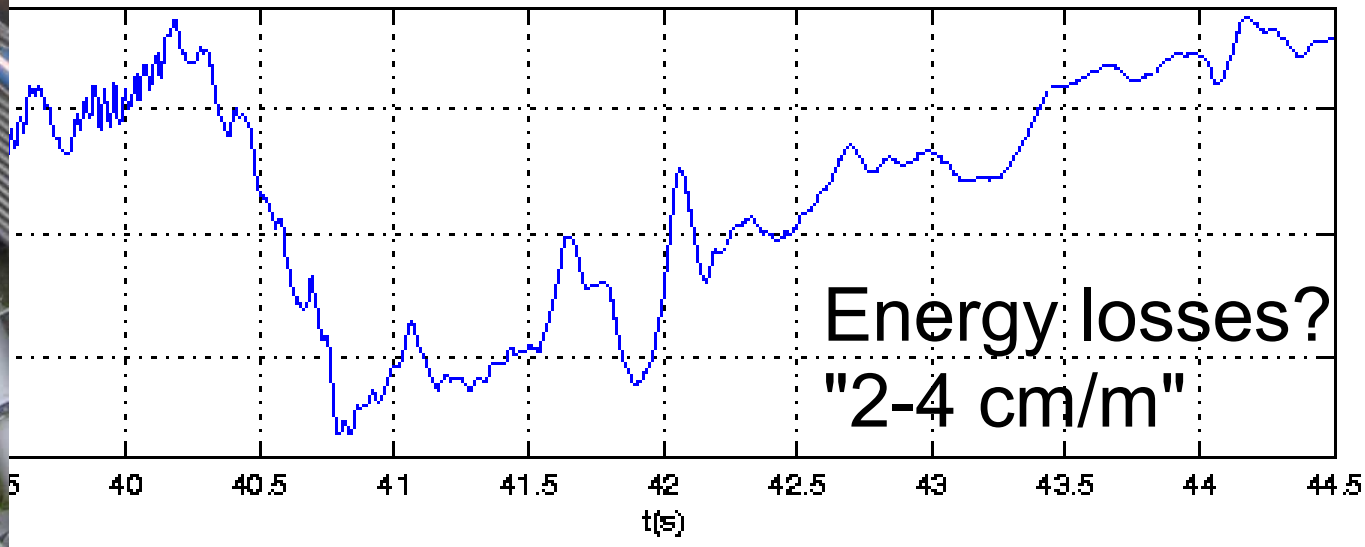
"Norwegian Loop"



Picture 17

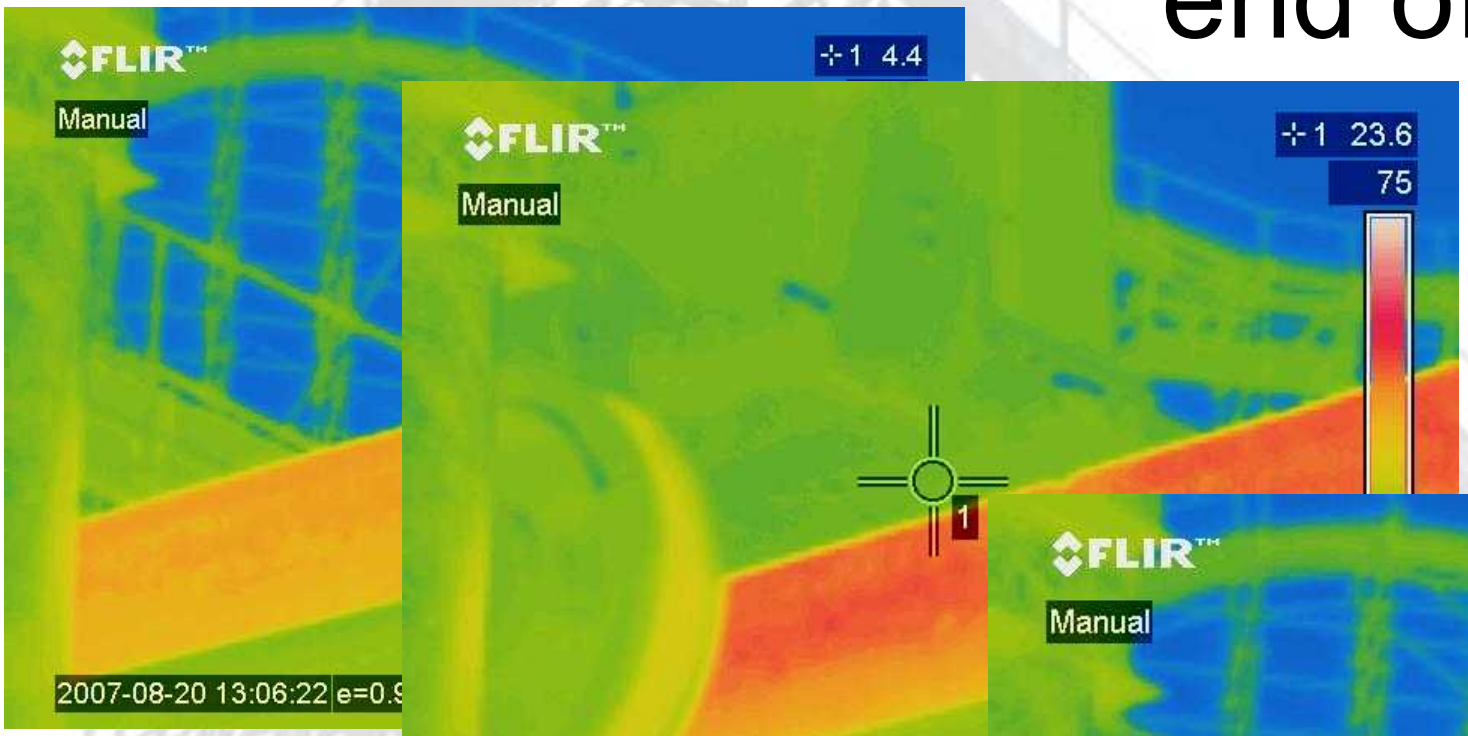
Launch and Brake





Energy losses?
"2-4 cm/m"

What happens to the energy at the end of the ride?



Projects for learning in Amusement Parks

Student Teachers:

- Physics and Technology –
- TEACHER OBSERVATORY + helping out
- Mathematics Education: Student-created problems and grading instructions

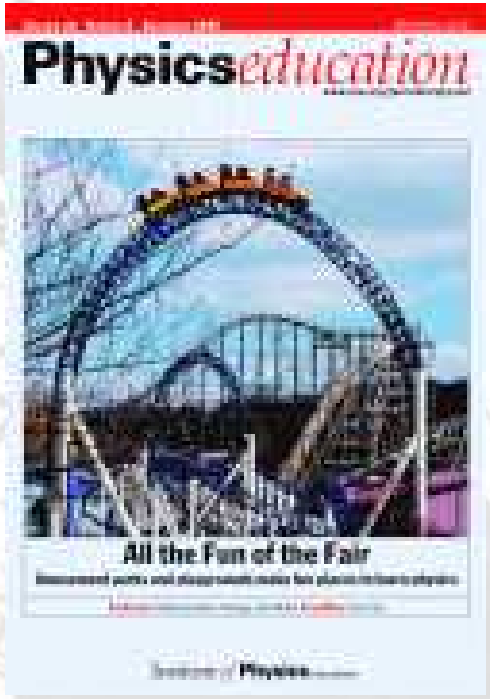
Engineering Physics (and Physics students)

- Forces and acceleration in roller coasters and other rides + reading drawings and patents

Teacher Days and school Physics/Science Days:

Liseberg – Tivoli – Gröna Lund – Tusenfryd

+ ...?



ACTIVITIES and INTERACTIONS

MINIMIZE TEACHER - STUDENT INTERACTION?

- Worksheet - to guide observations.
- Let students discover new things with worksheet as a guide.

STUDENT-STUDENT INTERACTIONS !

MAXIMIZE INTERACTION:

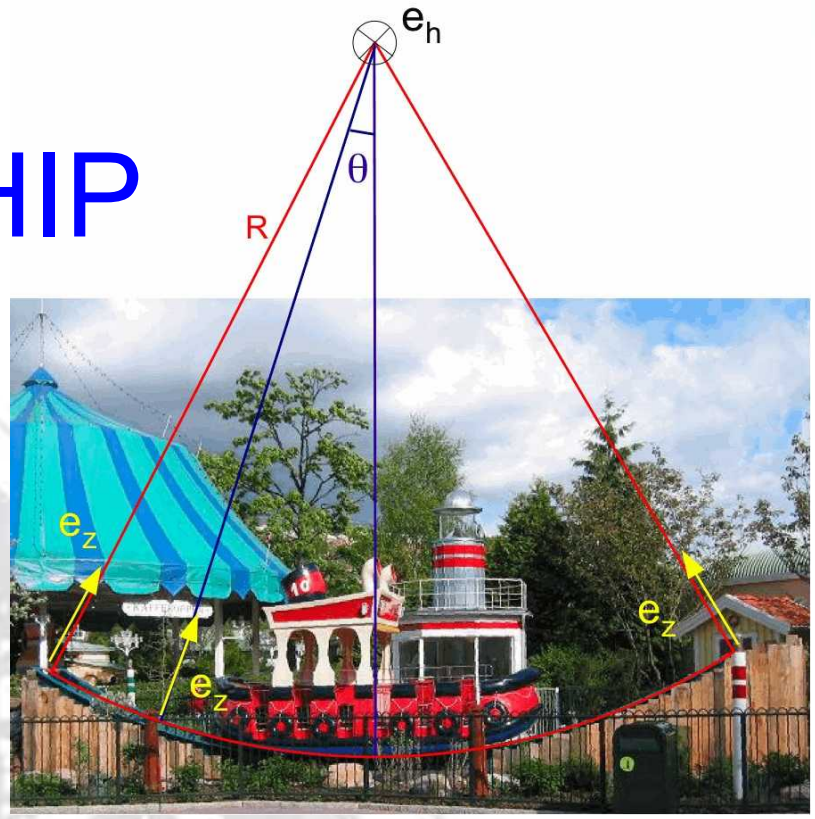
- Just-in-time teaching. Challenge observations, perceptions, contrast responses with experiences of the body
- Cognitive conflicts ("elicit, confront, resolve")

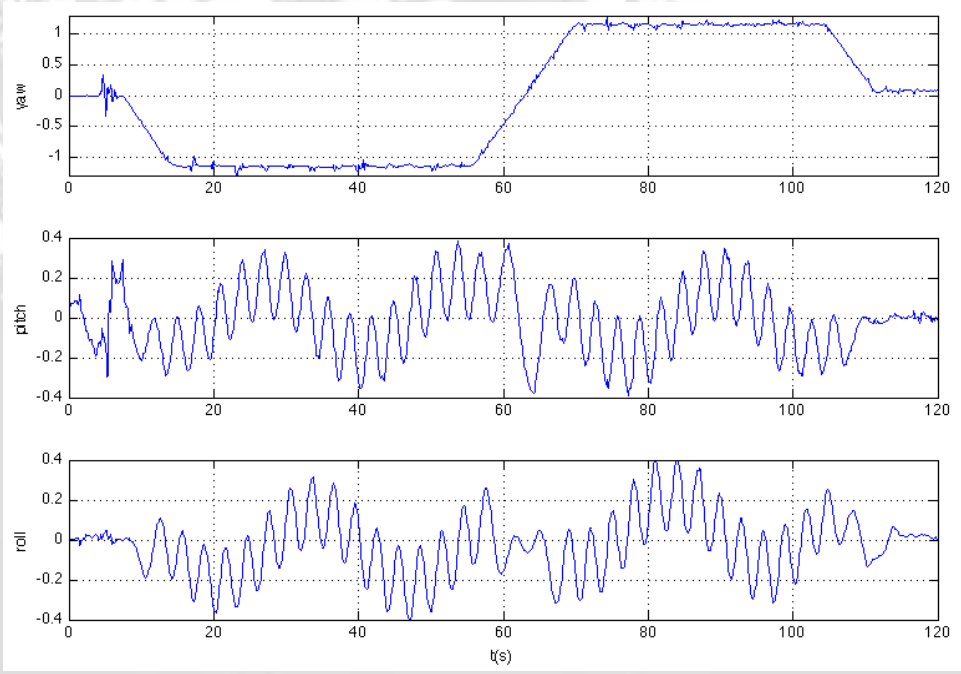
TEACHER OWNERSHIP!!!

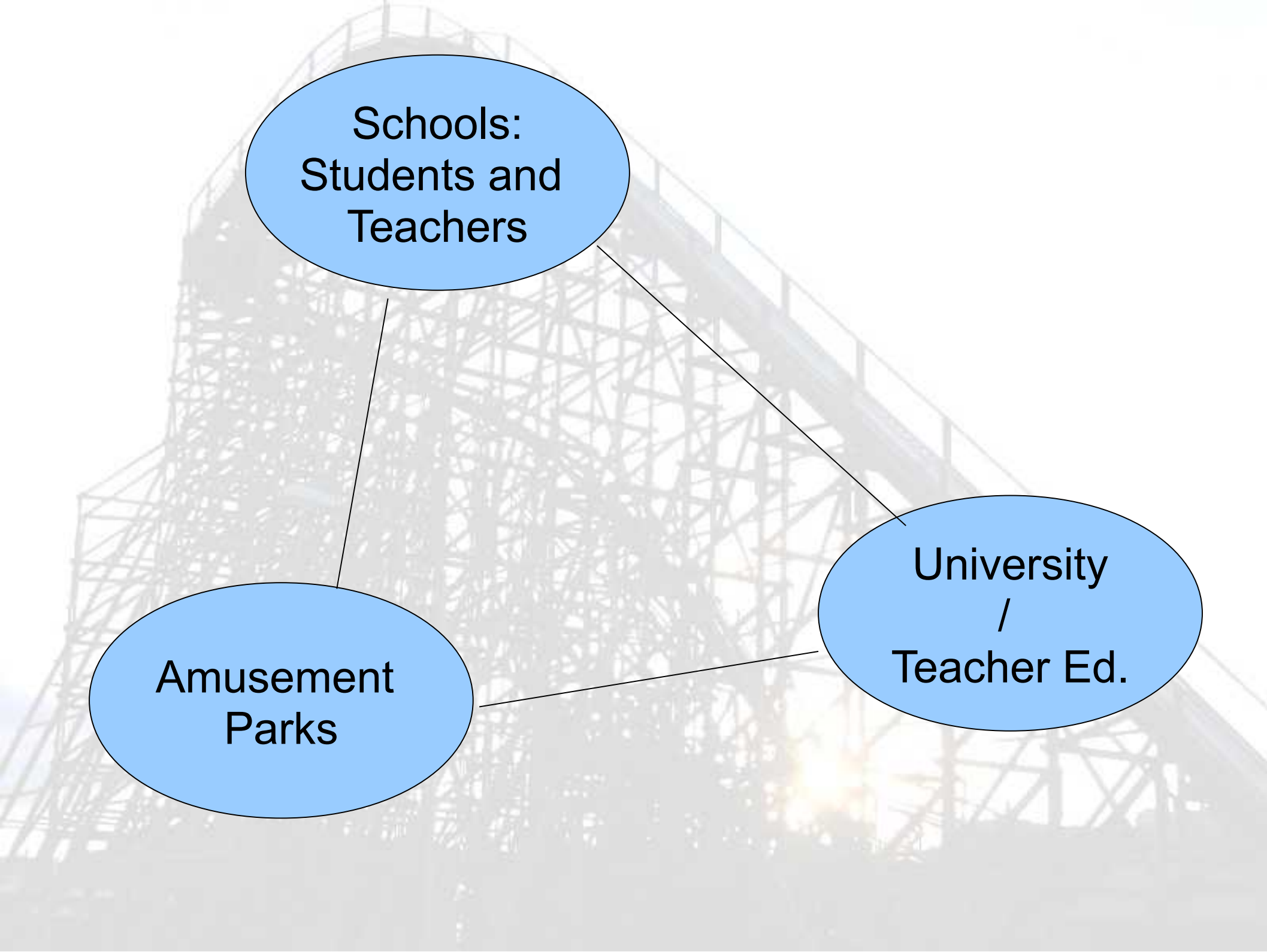
TEACHER OWNERSHIP

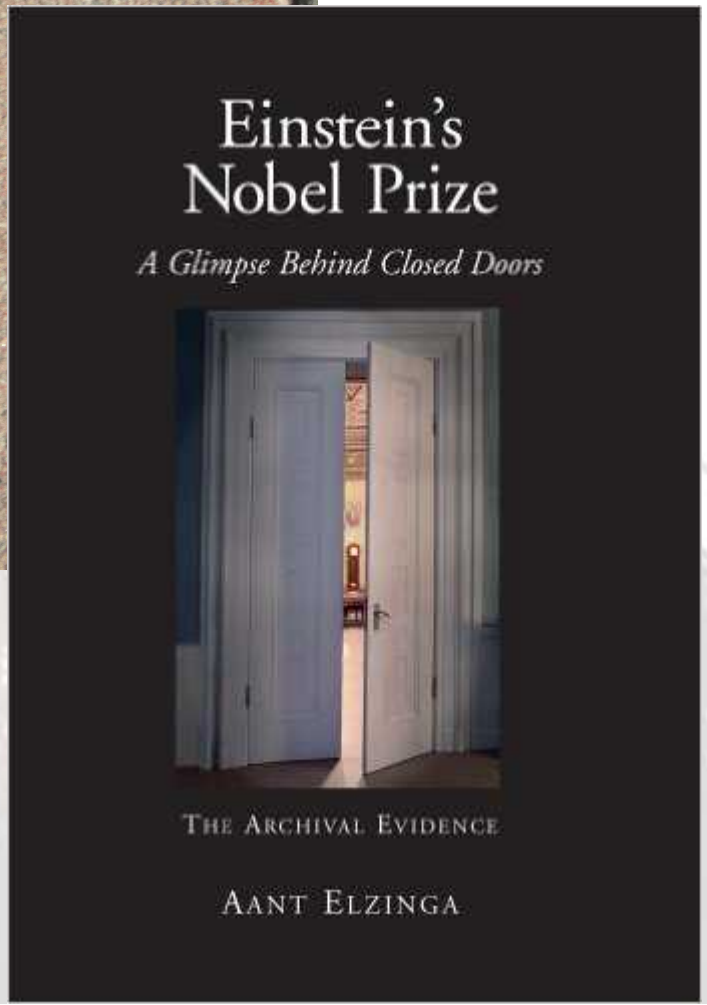
ÏT ... more like clothes than like fire; to get a benefit, you must make them a part of your personal space, tailored to your needs.

(Chris Dede 1995)






Schools:
Students and
Teachers
University
/
Teacher Ed.
Amusement
Parks



Nobel lecture: 11 July 1923

Articles about amusement park physics

Rotating swings - a theme with variations, Pendrill A-M, Physics Education, 51 (1) 15014 (open access) with video abstract

Liquids in accelerated motion, Fägerlind C-O and Pendrill A-M, Physics Education 50, 648-650 (2015)

Free fall and harmonic oscillations - analysing trampoline jumps, Pendrill A-M and Eager D, Physics Education 50, 64-70 (2015)

Studsmattematte - fritt fall och harmonisk svängningsrörelse Nämnaren 2015, nr 1, 37-42

The equivalence principle comes to school - falling objects and other middle school investigations, Pendrill A-M, Ekström P, Hansson L, Mars P, Ouattara L and Ryan U (2014) Physics Education, 49, 425 (open acces)

Teacher Roles in amusement parks, Pendrill A-M, Kozma C and Theve A, (2013) Proceedings ICPE-GIREP, p 591-599

Student investigations of forces in a roller coaster loop, Pendrill A-M (2013), European Journal of Physics, 34 1379 (Manuscript) (also "Fram mitten eller bak - var ska man sitta?" LMNT-nytt, nr 2 2013.)

Stopping a roller coaster train, Pendrill A-M, Karlsteen, M and Rödjegård, H (2012), Physics Education 47 (6), 728 (including a video abstract and an IR movie)

Acceleration and rotation in a pendulum ride, measured using an iPhone 4, Pendrill, A-M and Rohlén J (2011) Physics Education 46, 676-681 (Manuscript)

Roller Coaster Loop Shapes, Pendrill, A-M, (2005) Physics Education s517

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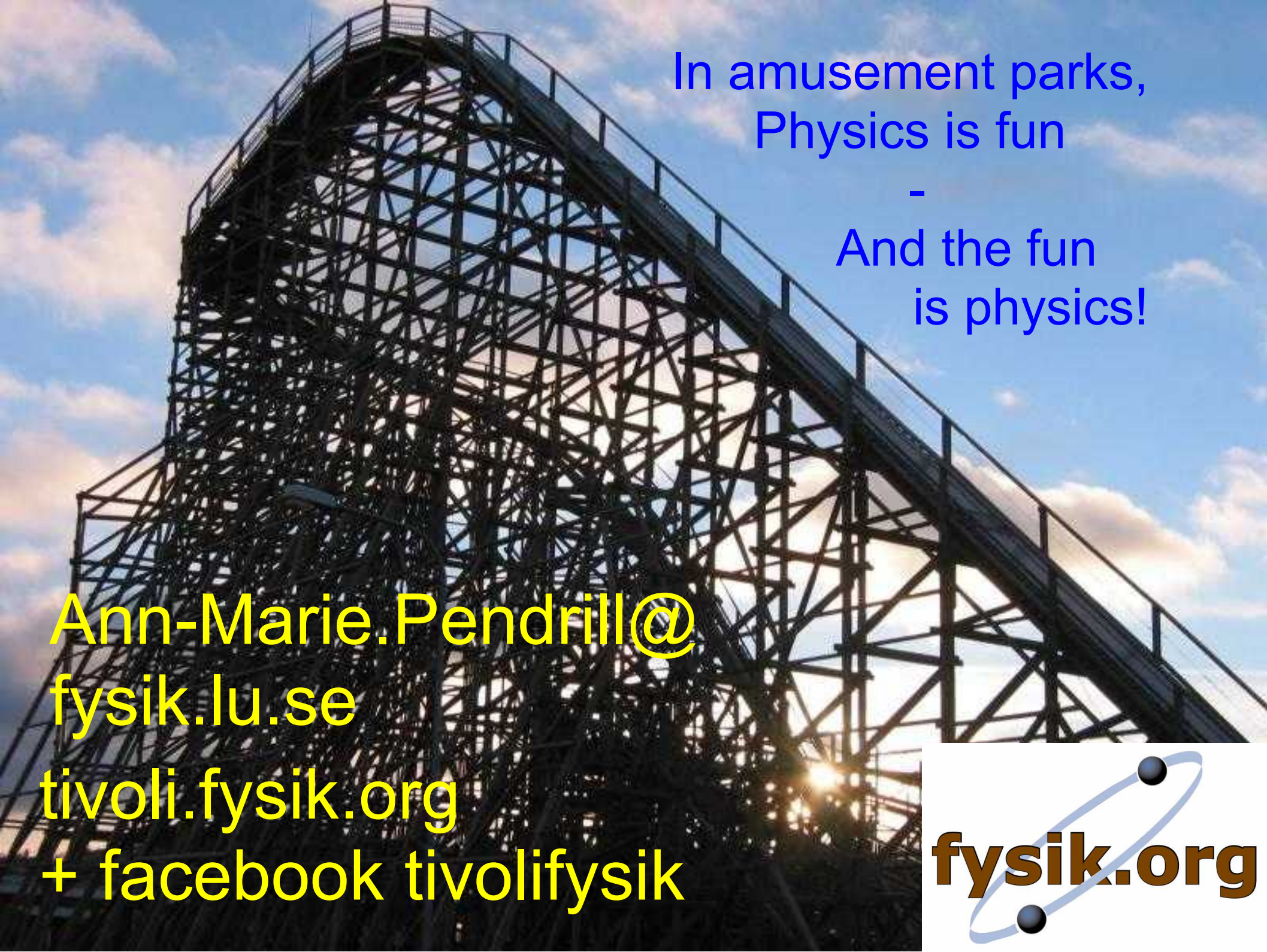
In amusement parks,
Physics is fun
-
And the fun
is physics!
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Video clips

- Energy conservation in roller coaster: Kanonen,
- Heating of the brakes: (2:47) (Top Hat)
- Teacup rides: Kaffekoppen
- Carousel (Gröna Lund + Liseberg)
- Wave Swinger (Slänggungan + Kättingflygaren + video-abstract) (+ combination)
- Mechanica (top + main rotation) (gondola rotation)
- Trampoline
- Helix: Heartline roll

Video - lekplats

- Sandby: Slide + fall
-

A With Newton and Einstein in an amusement park

An amusement park is full of physics examples: Essential phenomena, fundamental principles and classical experiments can be demonstrated in roller coasters, drop towers, carousels and swings. The equivalence between gravitational and inertial mass leads to the weightlessness of free fall, which can be experienced in drop towers, but also a in roller coaster at the top of loop or passing over a hill. Force and acceleration are known to be difficult concepts, but acceleration is not abstract when the "body" in Newton's laws is your own and the forces needed for acceleration are experienced throughout the body. The talk will present a few examples of learning in an amusement park.