Observation of the drying process in secondary school

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Teaching Physics Innovatively

New Learning Environments and Methods in Physics Education

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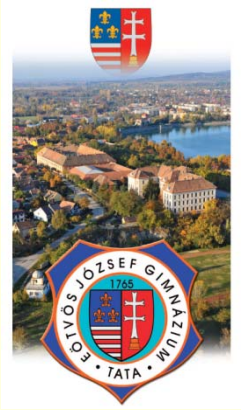
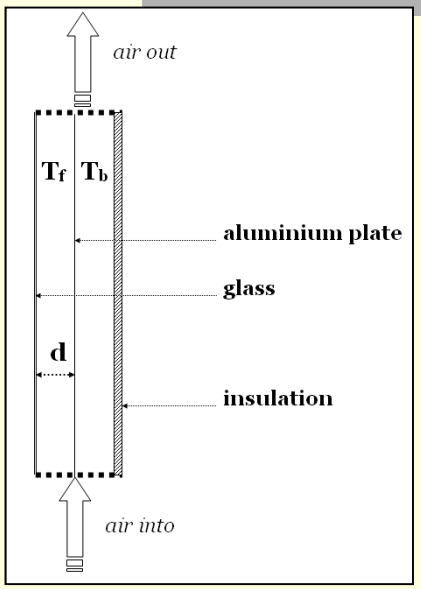


Extra curricular activity



Line schematic diagram of the collector

The solar dryer

Extra curricular activity

The efficiency of the collector:

$$\eta = \frac{P_{coll}}{P_{solarrad}}$$

$$P_{coll} = c_{air} \cdot \rho_{air} \cdot v \cdot A \cdot \Delta T$$

c_{air} - specific heat of air

ρ_{air} – density of air

v - velocity of flowing air

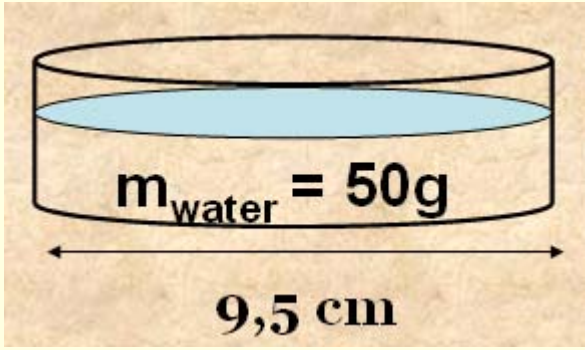
A - cross section of holes

ΔT - temperature difference

Extra curricular activity

The „efficiency" of the dryer:

$$\eta_{dryer} = \frac{L_{water} \cdot m_{evap}}{S_{solar\ rad} A_{coll} \Delta t} \approx 0.3\%$$



L_{water} - evaporation heat of water

m_{evapor} - mass of evaporated water

$P_{solarrad}$ - the solar radiation

A_{coll} - the useful surface of collector

Δt - the time needed

Measurements with the electric dryer

„Efficiency" of the electric dryer:

$$\eta_{el.dryer} = \frac{L_{water} \cdot \frac{\Delta m_{evap}}{\Delta t}}{P_{electric}} \cdot 100 = \frac{2{,}26 \cdot 10^{6}\, J/kg \cdot \frac{10^{-2}\, kg}{3600\, s}}{250\, W} \cdot 100 = 2{,}5\ \%$$

Electric > Solar

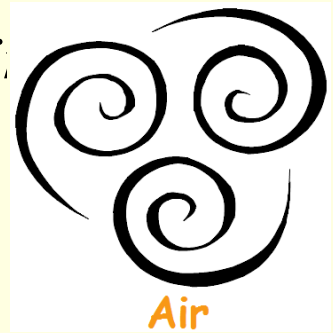
Measurements with the electric dryer

Air warming efficiency of the electric dryer: $\eta_{heat} = \dfrac{\dfrac{\Delta E_{flowingair}}{\Delta t}}{P_{electric}}$

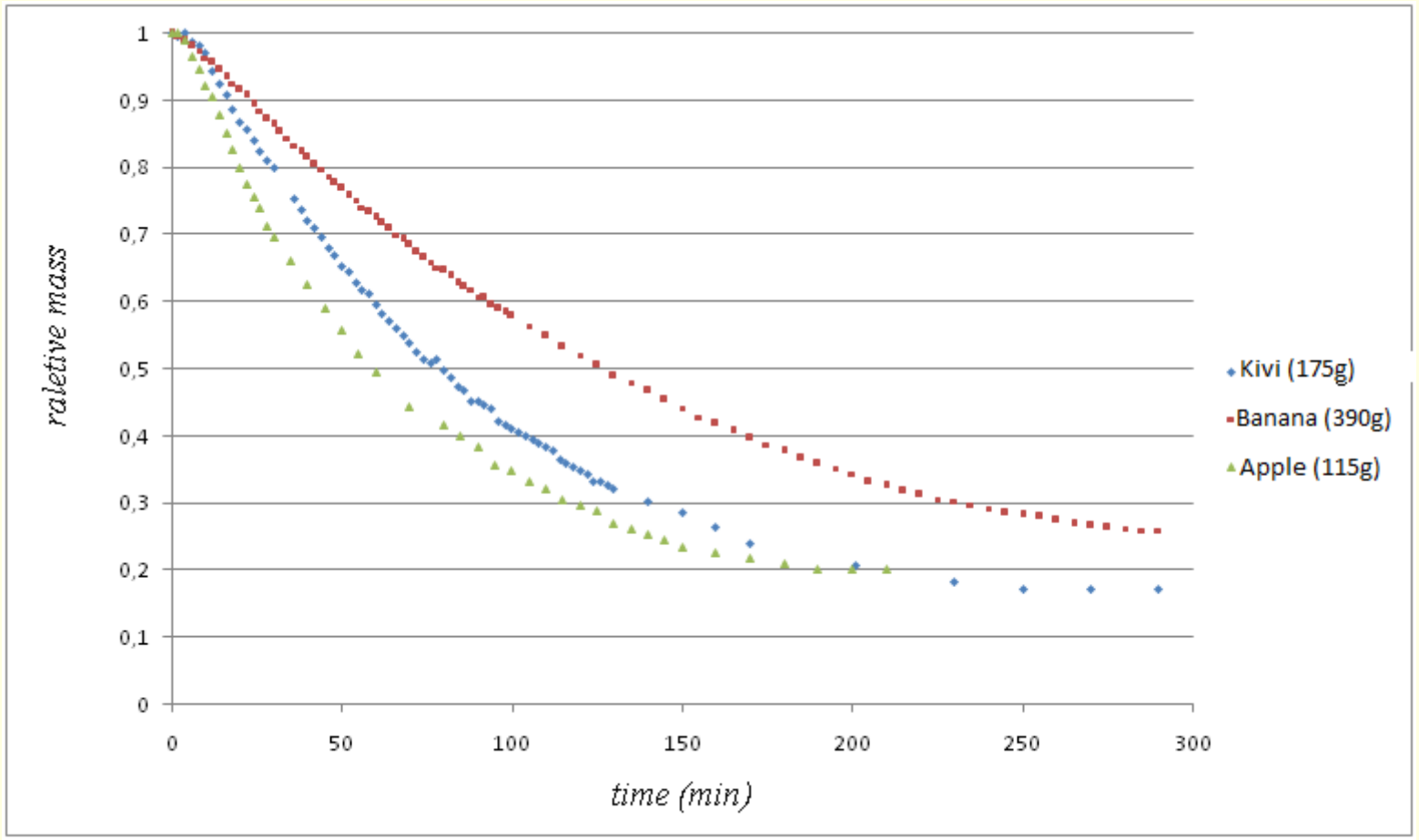
Determination of flowing air's amount

$$\Delta E_{flowingair} = C_{p,air} \cdot n_{flowingair} \cdot \Delta T_{flowingair}$$

$$\eta_{heat} = \frac{100W}{250W} \cdot 100 = 40$$



The Process of drying



The Process of drying

The set-up for measurements

The Process of drying

$$M\ (\%) = \frac{m_{water}}{m_{sample}} \cdot 100$$

Moisture content on dry basis (%)

$$MR = \frac{M - M_e}{M_i - M_e}$$

Moisture ratio

Table 2
Mathematical models widely used to describe the drying kinetics (Akpinar, Bicer, & Midilli, 2003; Akpinar, Bicer, & Yildiz, 2003; Akpinar et al., 2003a; Ertekin and Yaldiz, 2004; Günhan et al., 2005; Togrul and Pehlivan, 2003; Yaldiz and Ertekin, 2001)

Model no	Model name	Model
1	Newton	$MR = \exp(-kt)$
2	Page	$MR = \exp(-kt^n)$
3	Modified Page (I)	$MR = \exp[-(kt)^n]$
4	Modified Page (II)	$MR = \exp[(-kt)^n]$
5	Henderson and Pabis	$MR = a \cdot \exp(-kt)$
6	Logarithmic	$MR = a \cdot \exp(-kt) + c$
7	Two-term exponential	$MR = a \cdot \exp(-kt) + (1 - a)\exp(-k a t)$
8	Wang and Singh	$MR = 1 + at + bt^2$
9	Verma et al.	$MR = a \cdot \exp(-kt) + (1 - a)\exp(-g t)$

E.K. Akpinar, Y. Bicer, F. Cetinkaya: Modelling of thin layer drying of parsley leaves in a convective dryer and under open sun, J. of Food Engineering 75 (2006) 308-315

The Process of drying

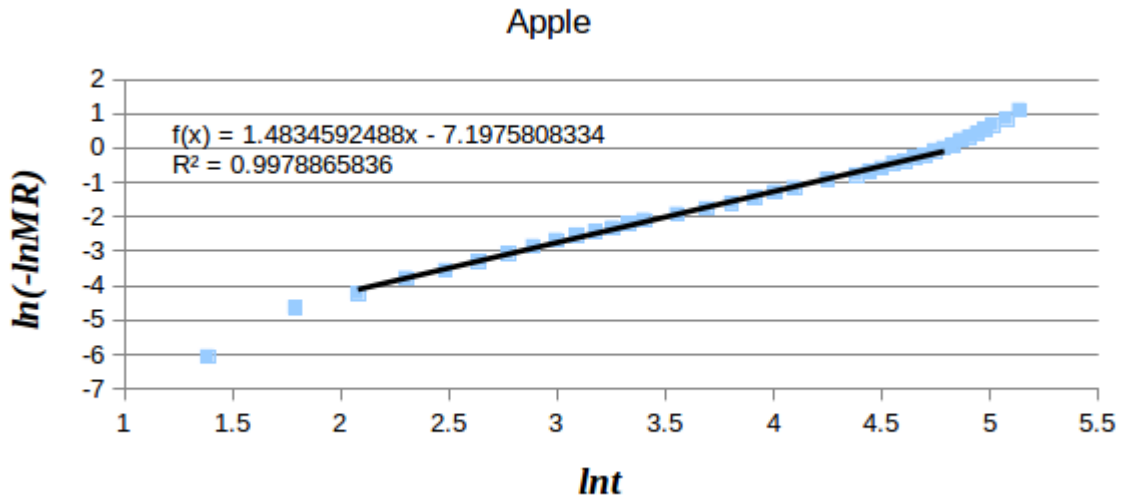
$$MR(t) = \exp\left[-(kt)^n\right]$$

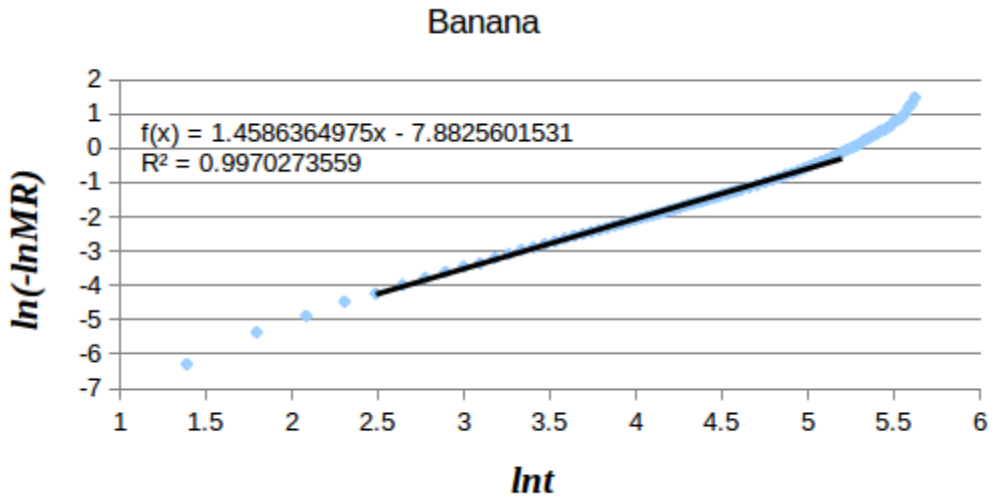
Linearization

$$\ln\left[-\ln(MR)\right] = n \cdot \ln(k) + n \cdot \ln(t)$$

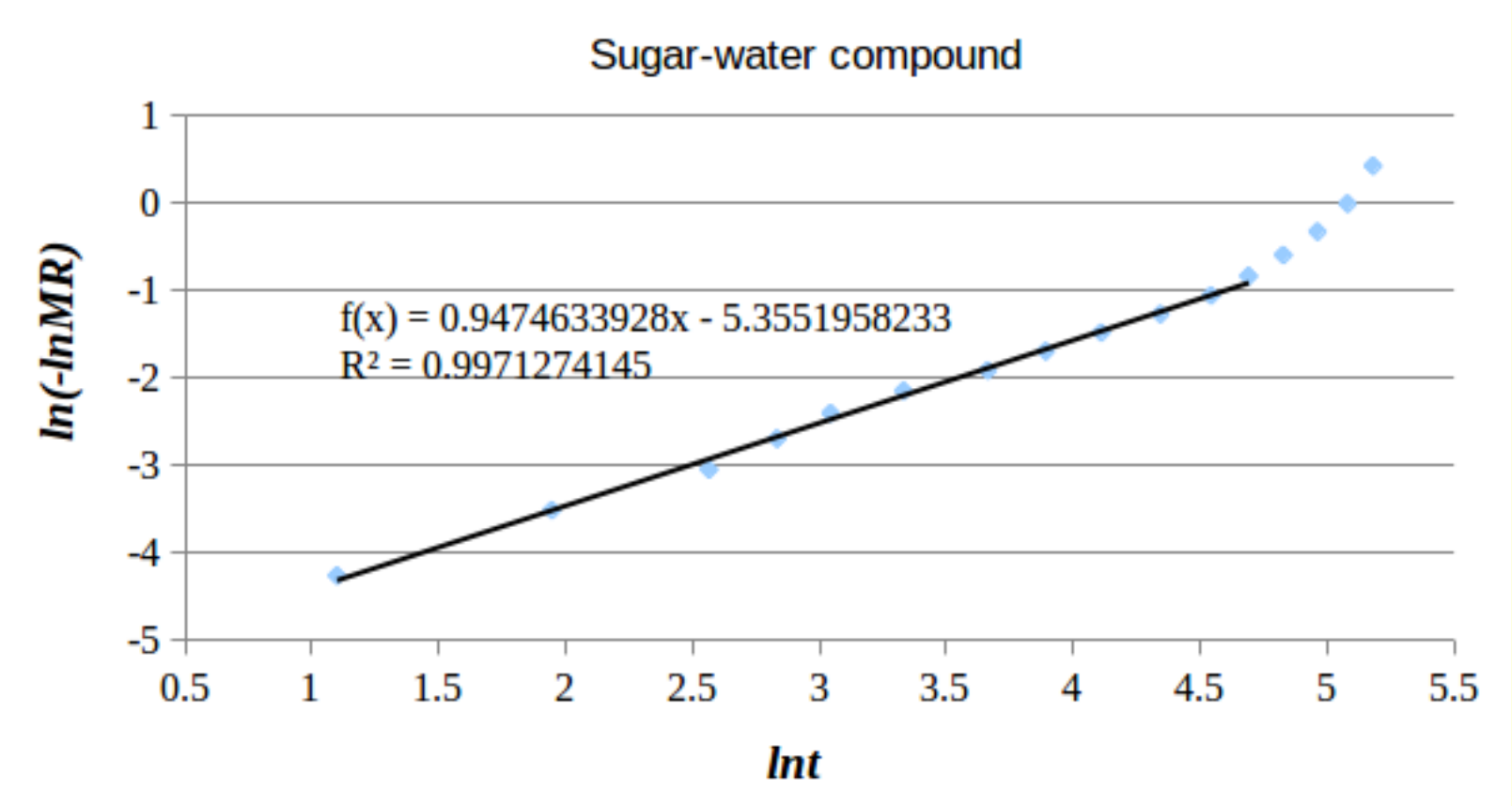
$$y = a + b \cdot x$$

Results


Apple
f(x) = 1.4834592488x - 7.1975808334
R² = 0.9978865836
ln(-lnMR)
lnt
2
1
0
-1
-2
-3
-4
-5
-6
-7
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5


Banana
f(x) = 1.4586364975x - 7.8825601531
R² = 0.9970273559
ln(-lnMR)
lnt
2
1
0
-1
-2
-3
-4
-5
-6
-7
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

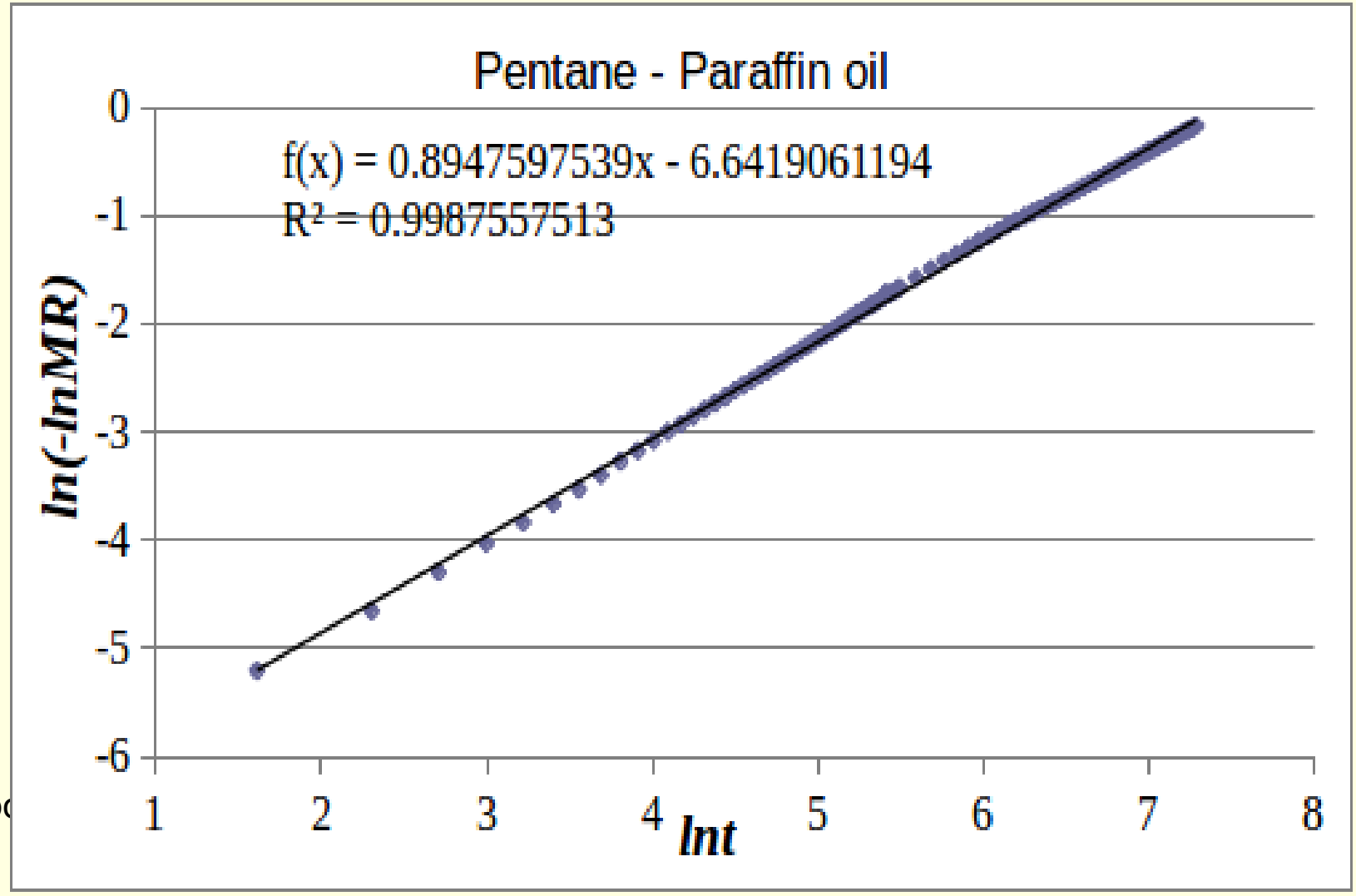
A physical picture:
Evaporation



* Evaporation of the compound is observed in an electric dryer, same circumstances as before

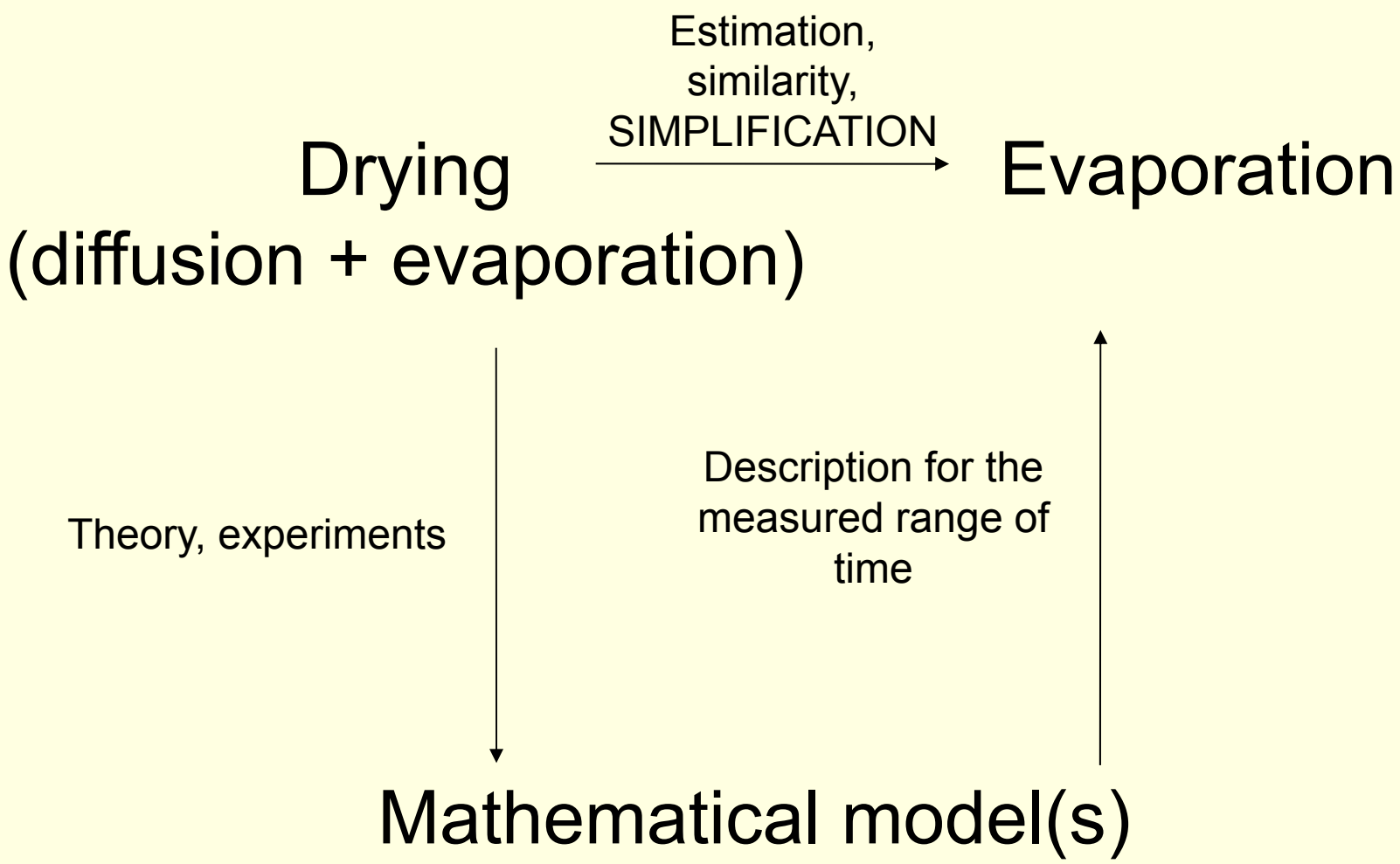
A physical picture:

Evaporation



* Evapo

A physical picture:
Evaporation



Application in classrooms

ELECTRIC DRYER
FRUITS/SUG-WAT*
+ KITCHEN BALANCE

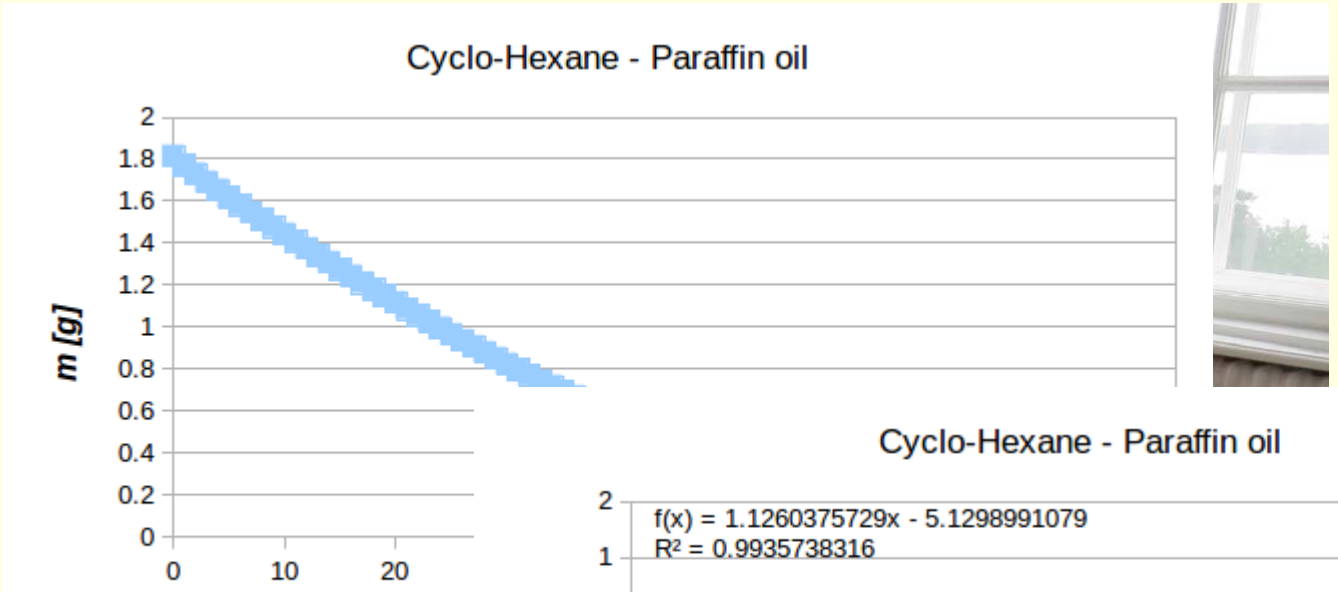
TIME

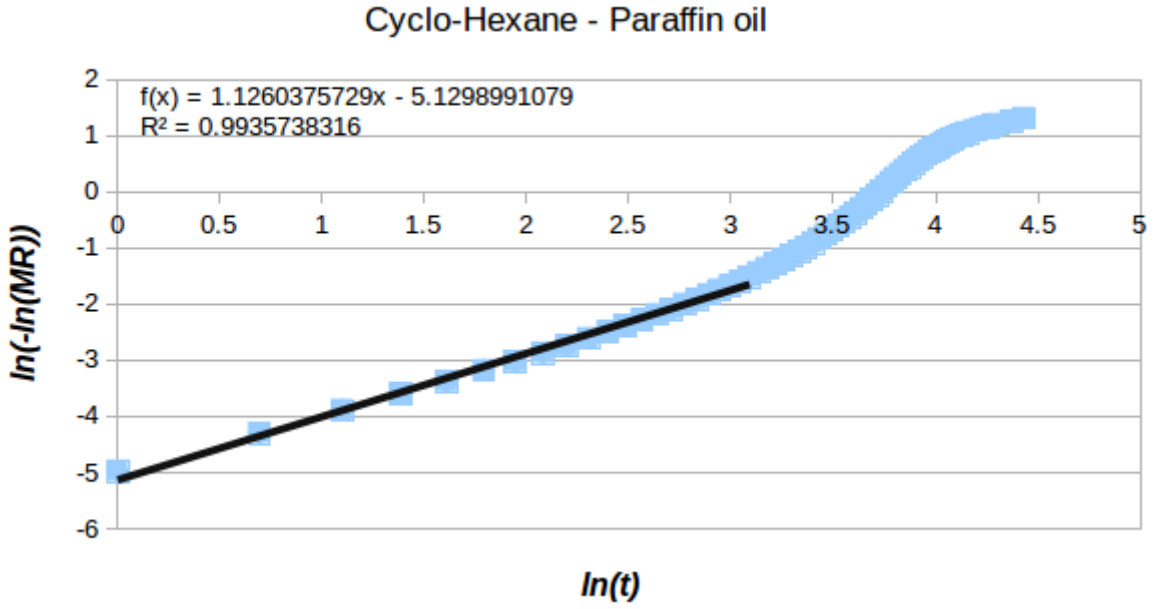
OPEN AIR
C-HEXANE&PARRAFIN
+ ANALYTIC BALANCE

OK

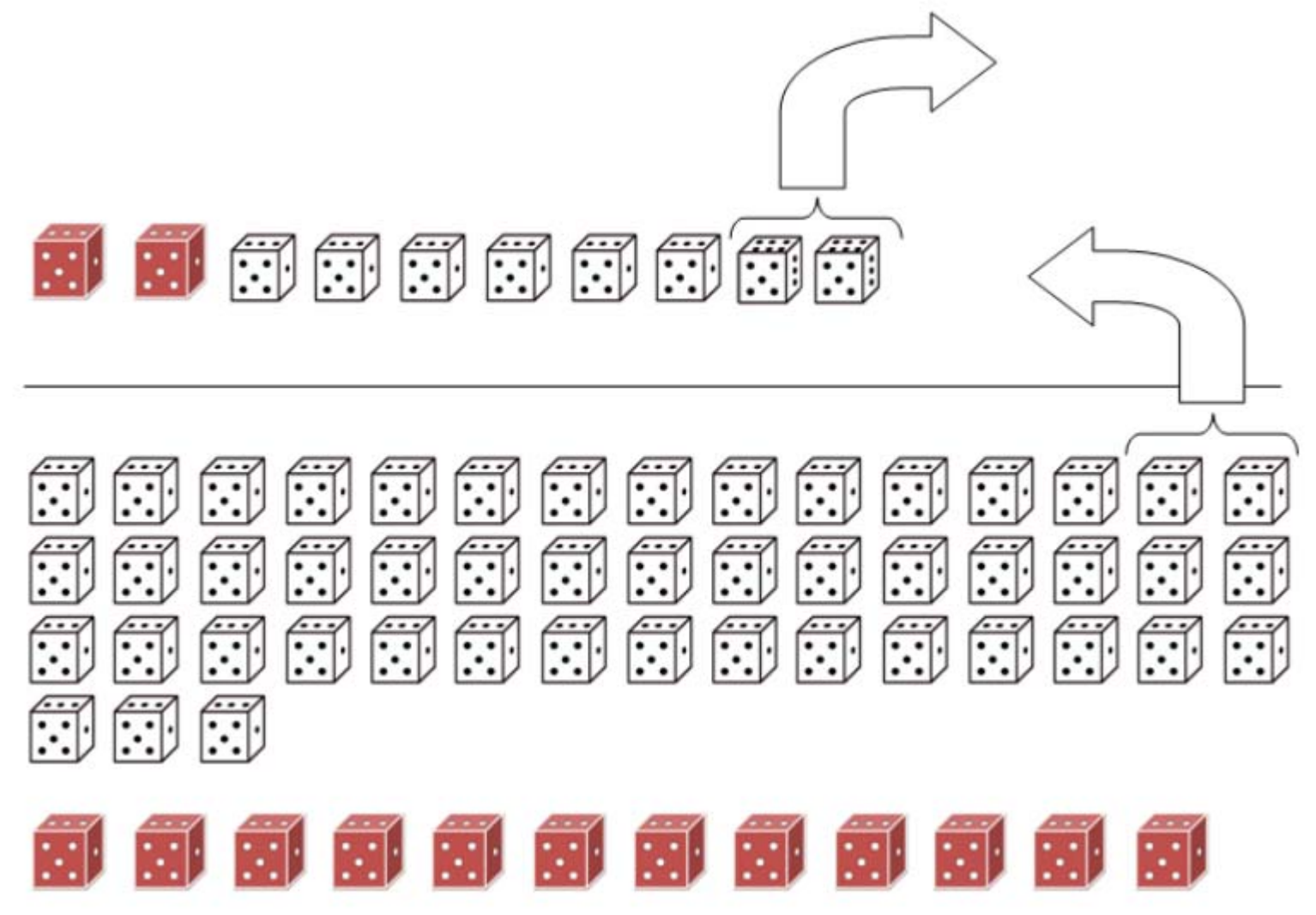
* Sugar-water compound

Application in classrooms

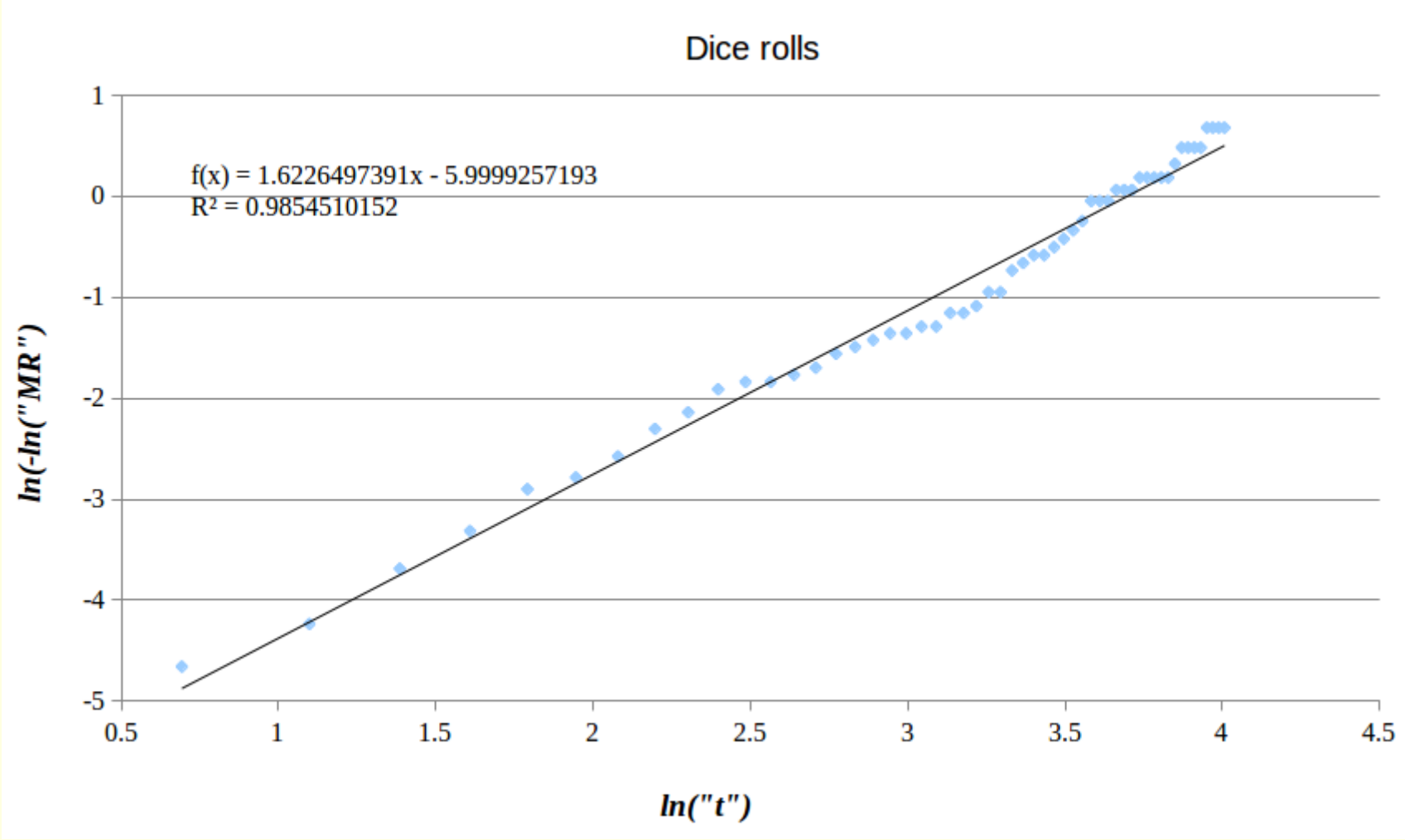




Dice - model



Dice - model


Dice rolls
f(x) = 1.6226497391x - 5.9999257193
R² = 0.9854510152
ln(-ln("MR"))
ln("t")
1
0
-1
-2
-3
-4
-5
0.5
1
1.5
2
2.5
3
3.5
4
4.5

Thank you for your attention!

References, papers

- *[1]* ***Szeidemann Á., Környezeti fizika a középiskolában, a napenergiás aszaló****, Juhász A. és Tél T. (szerk.), Fizikatanítás tartalmasan és érdekesen konferenciakötet, ELTE TTK (2009), ISBN 978-963-284-150-2, pp. 209-214.*
- *[2]* ***Szeidemann Á., Teaching facilities of solar energy in secondary schools****, Physics Competitions (2011), Vol. 13, Nr. 1., pp. 9-14.*
- *[3]* ***Szeidemann Á., Az energiafogalom szintézise a napenergiás aszalóval****, Tasnádi P. (szerk.), Természettudomány tanítása korszerűen és vonzóan, ELTE TTK (2011), ISBN 978-963-284-224-0, pp. 220-225.*
- *[4]* ***Szeidemann Á. és Beck R., A ciklonok szemléletes tanítása középiskolában****, Tasnádi P. (szerk.), Természettudomány tanítása korszerűen és vonzóan, ELTE TTK (2011), ISBN 978-963-284-224-0, pp. 632-637.*
- *[5]* ***Szeidemann Ákos, Fizika és földrajz határán – Tanítható-e a Coriolis-erő?****, Fizikai Szemle (2013), LXIII. Évf., 10. sz. pp. 352-357.*