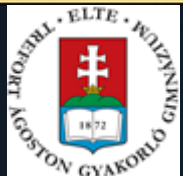


Real-time Charge Detector

with Smartphone Display



Authors: Fanni Vitkóczy & dr. Károly Piláth
ELTE Trefort Ágoston Secondary Training School

- Challenge: charges are invisible → difficult to teach electrostatics
- Traditional electroscopes: only detect presence, not sign or magnitude
- DIY tools exist but lack quantitative & visual feedback
- Goal: develop a simple, real-time, classroom-friendly device

• Inspirations

Nukleon 2014. március VII. évf. (2014) 155

Digitális multiméter az elektrosztatika tanításában
Digital Multimeter in Electrostatic Teaching
Zátonyi Sándor

Szent-Györgyi Albert Gimnázium, Szakközépiskola és Kollégium
5600 Békéscsaba, Gyulai út 53-57.

NUKLEON
NUKLÉÁRIS TUDOMÁNYOS MŰSZAKI FOLYÓIRAT

2014

Physics Education **IOPscience**

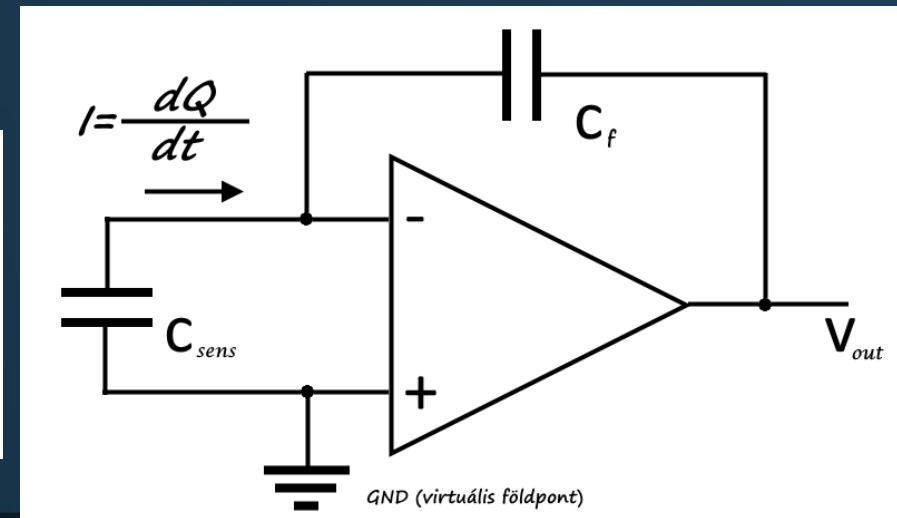
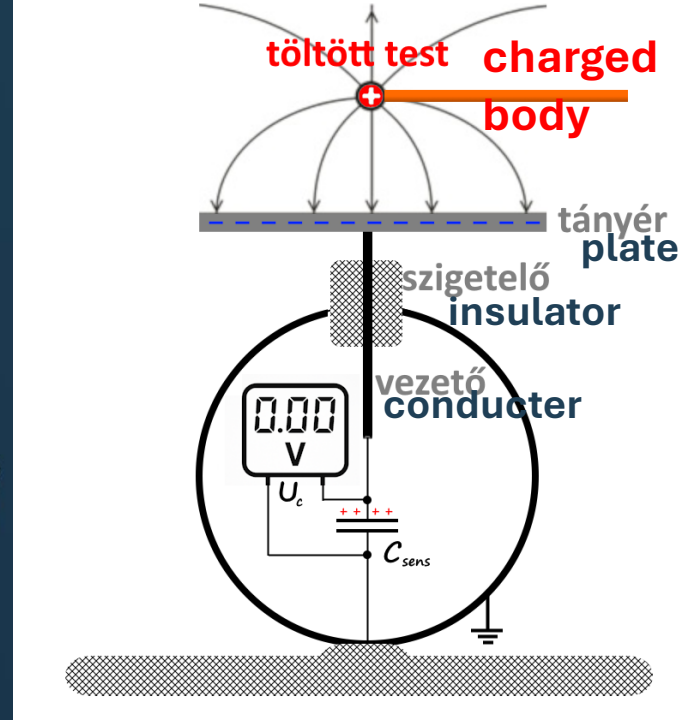
An electronic gold leaf electroscope
G R Davies
Published under licence by IOP Publishing Ltd
[Physics Education, Volume 9, Number 6](#)
Citation G R Davies 1974 *Phys. Educ.* 9 393
DOI 10.1088/0031-9120/9/6/305

1974

Motivation & Background

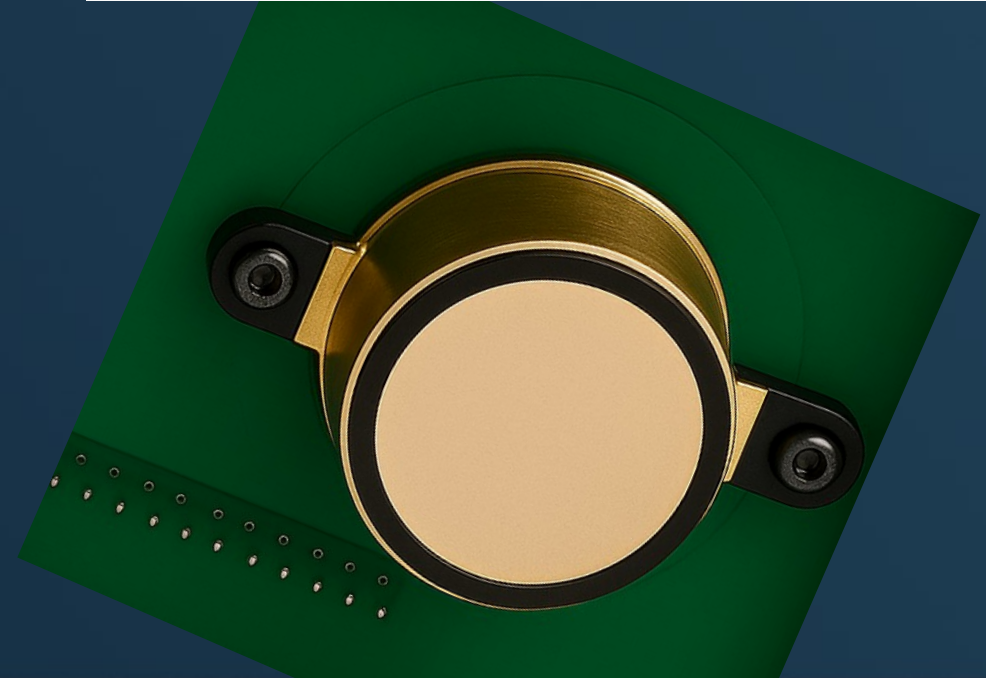
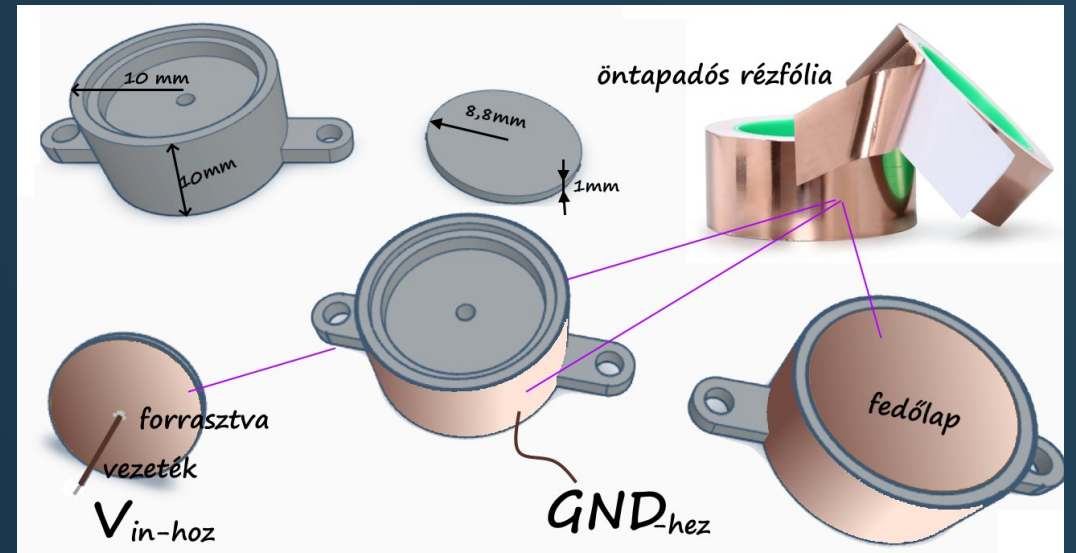
- Parallel-plate capacitor in an external electric field
- Induced charge measured with a charge amplifier
- ESP32 microcontroller converts to digital signal
- Output via Bluetooth to smartphone/tablet

$$V_{out} = \frac{1}{C_f} \int \frac{dQ}{dt} dt = \frac{Q}{C_f}$$



Principle of Operation

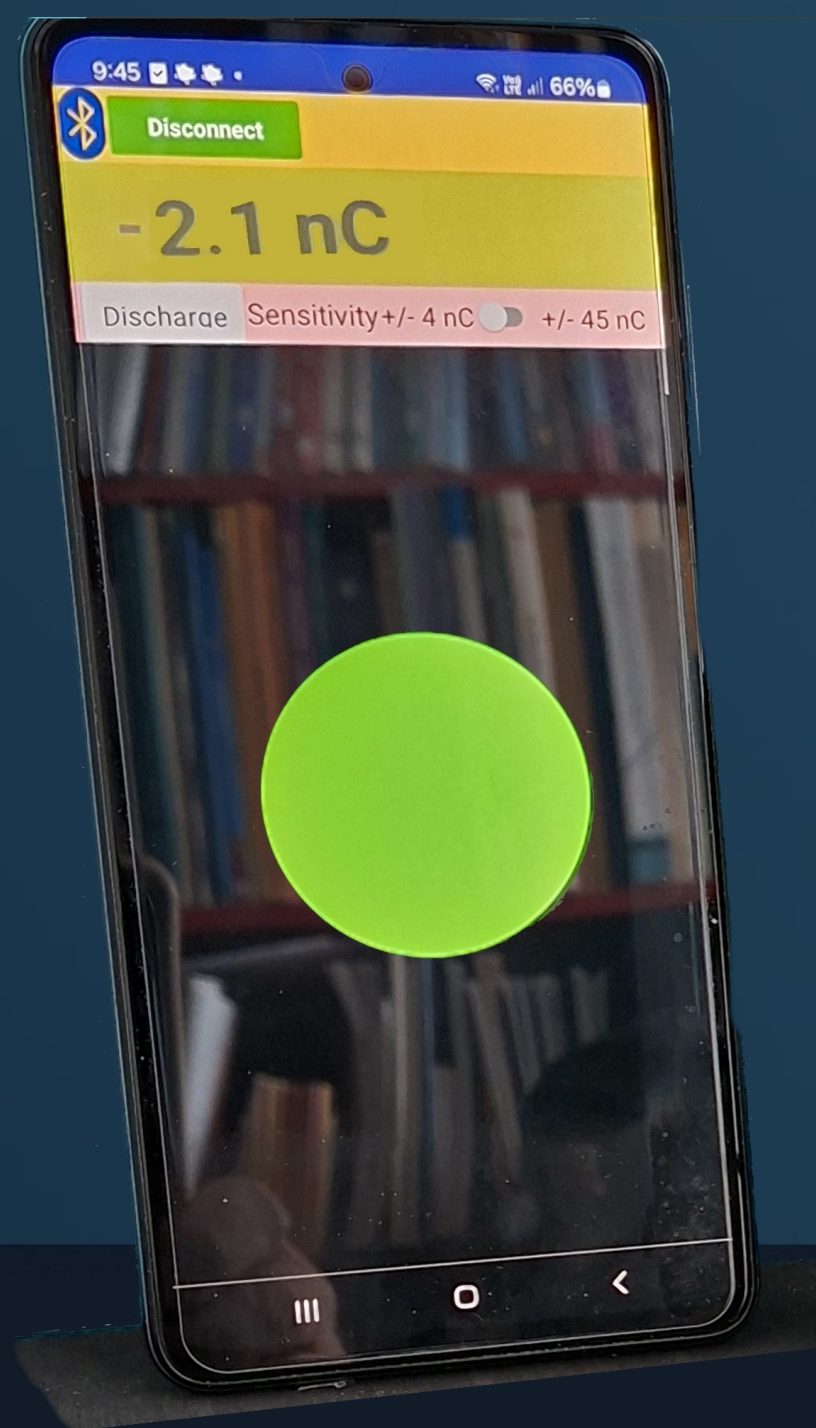
- 3D-printed capacitor with copper foil
- Charge amplifier selectable feedback capacitors
- Built-in LED display
color = sign
brightness = amount
- Bluetooth communication to Android app



Instrument Design

- Developed in MIT App Inventor
- Updates every 20 ms
- Visual display: colored circle (red = positive, green = negative, grey = neutral)
- Remote zeroing & sensitivity switching

Smartphone Application



- Working prototype successfully tested with students
- Stable, portable, easy to use
- Open-source: PCB design, 3D-print files, and code on GitHub



<https://github.com/pkarcsi55/-Smart-Qmeter>



Prototype and Classroom Use

- Charging by friction – PVC rod & wool, polarity shown on phone
- Charge transfer – charged object → aluminum can, charge retained
- Electrostatic induction – can grounded by finger → opposite charge remains
- Photoelectric effect – UV light discharges negatively charged aluminum

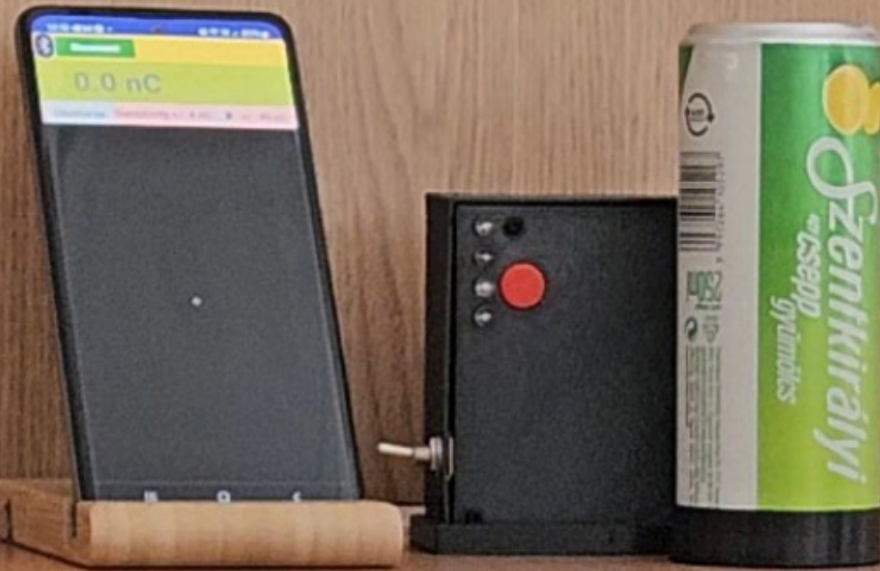


Demonstration Experiments (short videos)



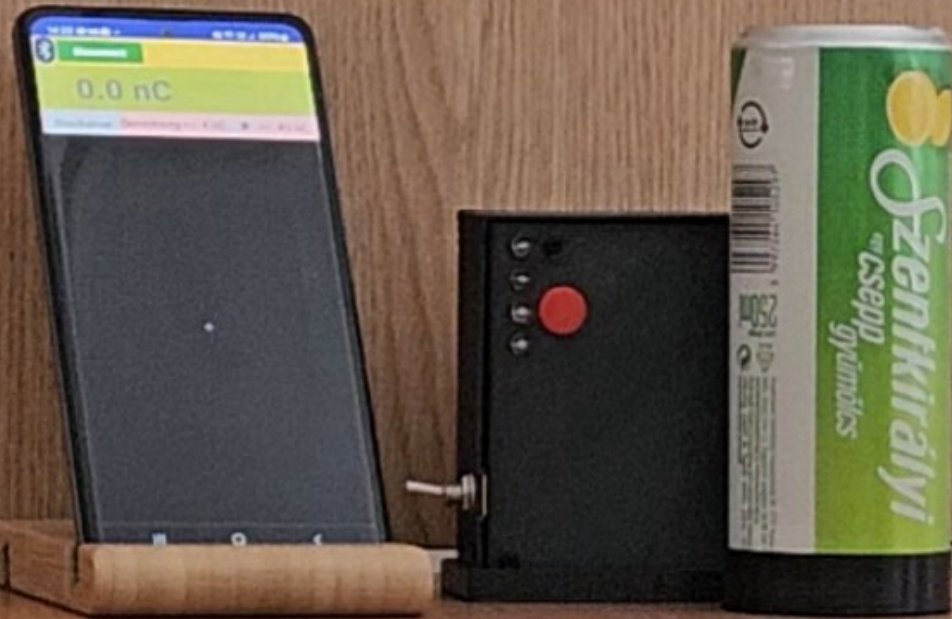
Charging by friction

PVC rod & wool, polarity shown on phone



Charge transfer

Charged object \rightarrow aluminum can, charge retained



Electrostatic induction

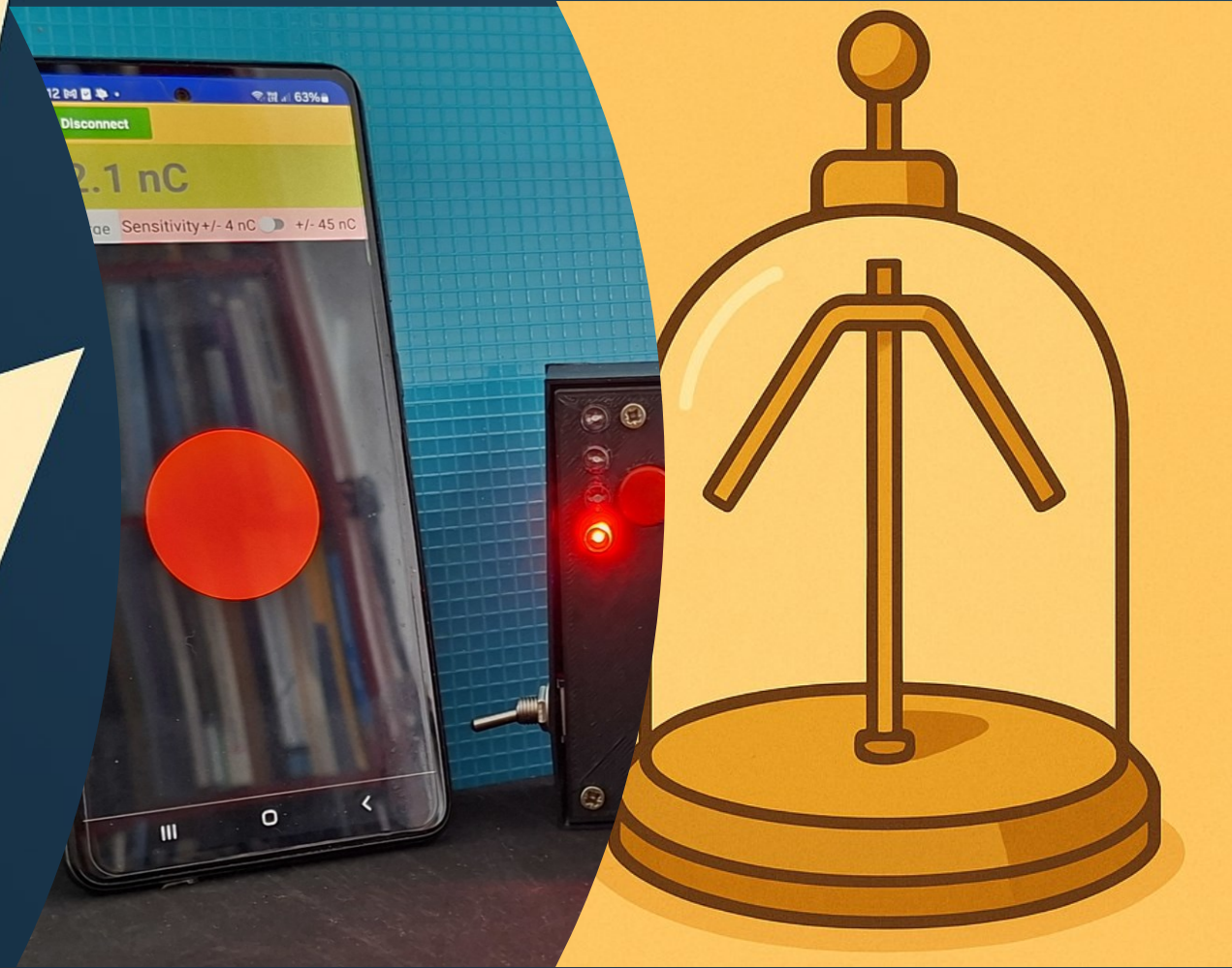
Can grounded by finger →
opposite charge remains



Photoelectric effect

UV light discharges negatively charged aluminum

- Engages students with direct, visible feedback
- Connects classical experiments with modern technology (Bluetooth, apps)
- Demonstrates abstract concepts like induction, field strength, photoelectric effect
- Students more active and motivated in experiments



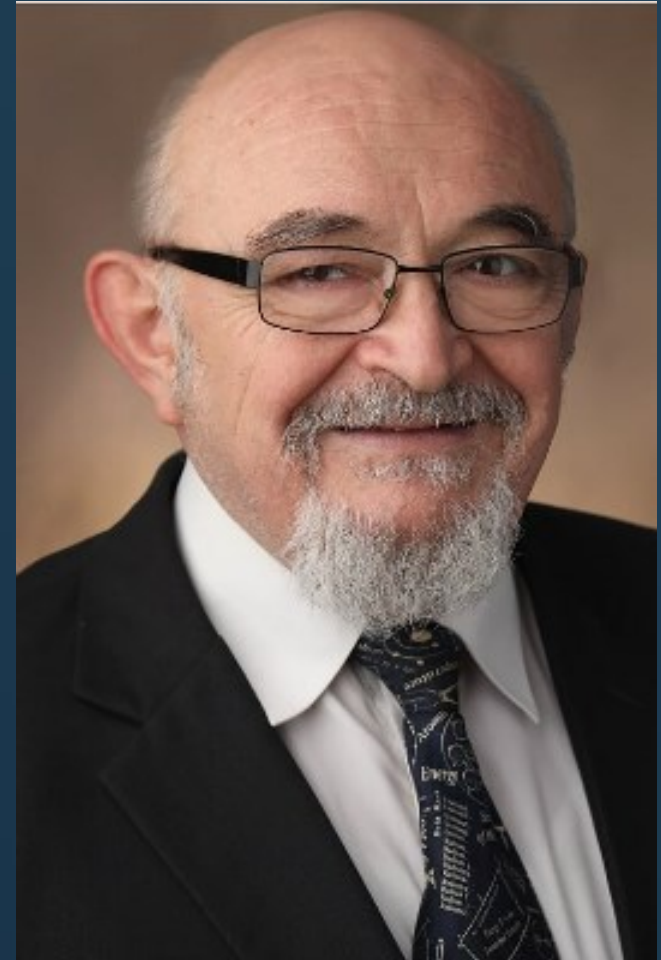
Educational Impact

- Device modernizes electrostatics teaching
- Low-cost, DIY, reproducible in school labs
- Future work: classroom sets, further experiments



Conclusion & Outlook

**Thank you
for
your
attention!**



MPTL 2025. Budapest

[1] [Super-sensitive Electric Field Detector](#)

[2] [Electric Field Strength Detector Using CD4011BE IC](#)

[3] [Zátonyi Sándor: Digitális multiméter az elektrosztatika tanításában](#)

[4] [G R Davies An electronic gold leaf electroscope 1974 Phys. Educ. 9 393](#)

[5] [Understanding and Implementing Charge Amplifiers for Piezoelectric Sensor Systems](#)

[6] [DIY Science Experiments – Chemistry Education Lab Inducts Learners into Hot Research Topics](#)

Documentation and technical details:
<https://github.com/pkarcsi55/-Smart-Qmeter>

References