# BRAZILIAM TEAM


17th IYPT - AUSTRALIA - Brisbane - 24th June to 1st July

# 3. ELECTRIC PENDULUM

Use a thread to suspend a ball between the plates of a capacitor. When the plates are charged tha ball will start to oscillate. What does the period of the oscillations depend on?

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# *Introduction*

- History
- Electricity
- Conditions
- Experiment
- Source of Errors
- Conclusions

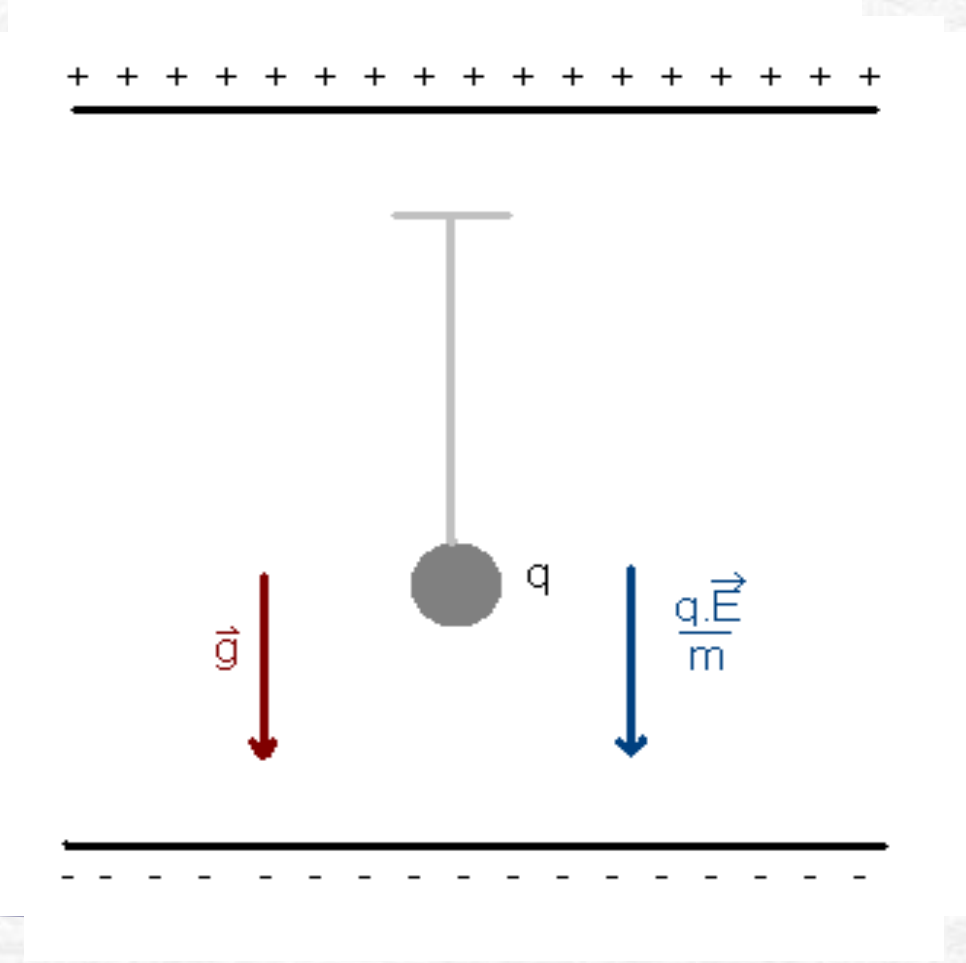
# History

- A way to understand electricity
- This kind of pendulum has been used in house watches

# *Electricity*

- Charges: positive
  negative
- Electric field between the plates: constant $E = \frac{Q}{d}$

# Conditions




- The ball must be charged

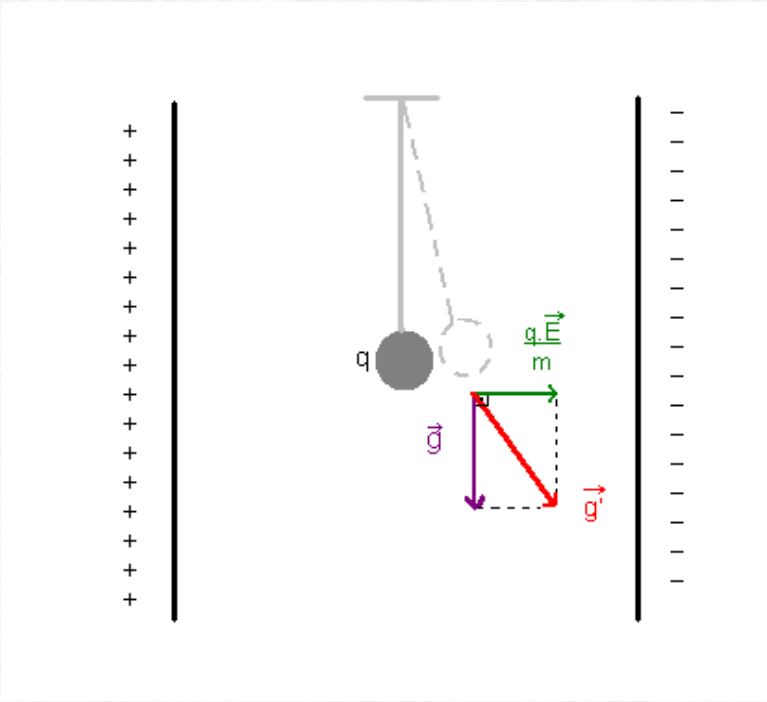
- The capacitor's plates cannot be horizontally parallel

# *Mathematical Analysis*

$$\mathbf{F} = q.\mathbf{E}$$

$$m.\mathbf{a} = q.\mathbf{E}$$

$$\mathbf{a} = \frac{q.\mathbf{E}}{m}$$




a= acceleration due to the electrical field

# *Analysis*

- New position of balance
- Electric force is strong enough to make tha ball pass this position
- The pendulum oscillates due to this force (in simple harmonic movement)

If the plates of the capacitor are vertical and parallel:

$\vec{g}$ and $\vec{a}$ are perpendicular and, hence, the vetorial sum results in

$$g' = \sqrt{g^2 + \frac{q^2 . E^2}{m^2}}$$

As the period of a pendulum is given by

$$T = 2\pi\sqrt{\frac{L}{g'}}$$

One can finally write for the period:

$$T = 2\pi \sqrt{\frac{L}{\sqrt{g^2 + \frac{q^2 . E^2}{m^2}}}}$$

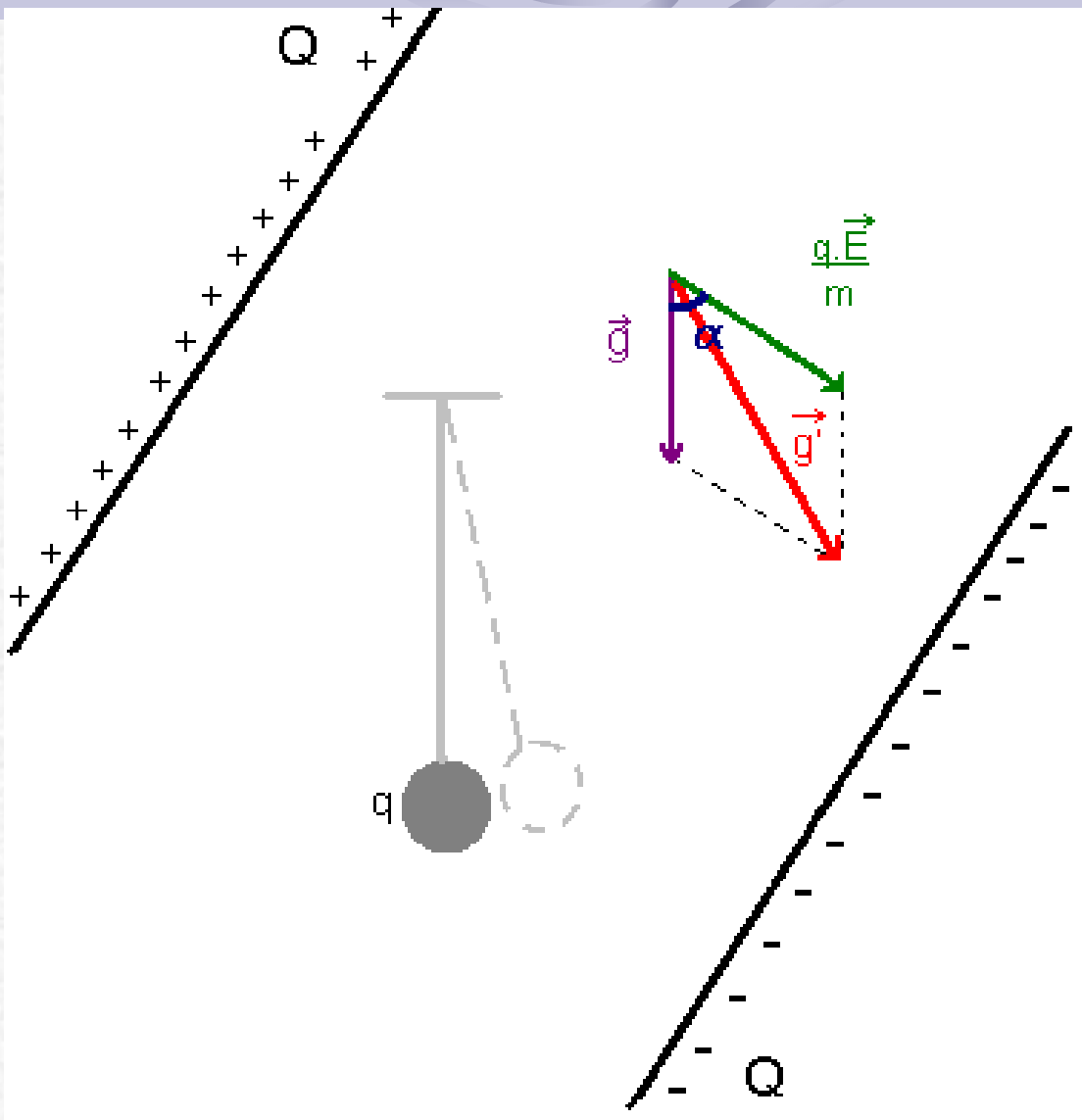
Given that the electric field is uniform, it can be calculated by:

$$E = \frac{\sigma}{\varepsilon} = \frac{Q}{A\varepsilon}$$

(where $\sigma$ = superficial charge density;
A= plate's area and ε= environment's electric permissivity)

Therefore, the equation for the period of the pendulum becomes:

$$T = 2\pi \sqrt{\frac{L}{\sqrt{g^2 + \frac{q^2.Q^2}{m^2.A^2.\varepsilon^2}}}}$$


Q
q
$\vec{g}$
$\frac{q.\vec{E}}{m}$
$\vec{g'}$
α
Q

In this case, the vetorial sum is:

$$g' = \sqrt{g^2 + \frac{q^2 . E^2}{m^2} + 2 . g . \frac{q . E}{m} . \cos \alpha}$$

Equally to the last case, we have:

$$T = 2\pi \sqrt{\frac{L}{\sqrt{g^2 + \frac{q^2.Q^2}{m^2.A^2.\varepsilon^2} + \frac{2.g.q.Q.\cos\alpha}{m.A.\varepsilon}}}}$$

# *Source of Errors*

- The ball discharged very quickly because the weather was umid
- There was no way how to measure the charge of the ball

# Conclusion

The period depend on:

- The mass of the ball (m);
- The electric field of the capacitor (E) and of the ball (q);
- The surface (A) and the distance between the plates;
- The length (L) of the thread;

# Experiment