## Challenge 3, Waves and Oscillations

Submission date: 15. November

## Pendulum in the capacitor (14 points)

In this task we investigate the behaviour of a pendulum in an electric field. For this purpose we consider an (ideal) plate capacitor with plate area  $A = 1 \text{ m}^2$  and distance d = 20 cm and a small sphere with mass m = 5 g, which is suspended from a thread of length l = 10 cm.

## Part A. Electric field (3 points)

i. (1 pt.) Calculate the capacitance C of the capacitor.

ii. (2 pt.) What is the voltage and electric field when the charge  $Q = \pm 2 \mu C$  resides on the capacitor plates?

## Part B. Oscillation (11 points)

If you could not solve the previous tasks, use an electric field of  $E=2.26\,{\rm MV}\cdot{\rm m}^{-1}$  for the following tasks.

i. (2 pt.) In the middle of the condenser, whose plates are parallel to the yz -plane (i.e. perpendicular to gravity), we now place our pendulum. The sphere is charged with q = 200 nC. Sketch which forces act on the sphere and the resulting force.

ii. (2 pt.) What angle does the pendulum assume with the vertical when at rest?

iii. (5 pt.) If the pendulum is deflected by a small angle from this rest position, it will perform an (approximately harmonic) oscillation. Calculate the frequency of this oscillation! Note: For  $x \ll 1 \sin x \approx x$  holds.

iv. (2 pt.) How does the frequency of the oscillation change if the voltage of the capacitor is kept constant and the distance between the plates is increased by  $\Delta d = 5 \text{ cm}$ ?