Exercise 3: Swing pendulum

We hold a swing pendulum as shown in the figure and release. The pendulum is then at a height h = 13 cm above the bottom point. We disregard air resistance and friction.

a) Explain that the mechanical energy is conserved in the system.

b) What is the speed at the bottom of the pendulum motion?

As the ball is at the lowest point in the movement, the thread breaks. Just then the ball is 1.0 m above the ground.

c) How fast will it hit the floor?

a) The mechanical energy is the sum of the kinetic energy and the potential energy. While the pendulum swings, there is a constant conversion between these 2, where the sum remains constant. At the highest point, the mechanical energy is equal to the potential energy while kinetic energy is zero, while at the lowest point the mechanical energy is equal to the kinetic energy while potential energy is zero.

b) The mechanical energy is:

$E = mgh = m * 9.81 * 0.13 = 1.28m$

At the lowest point the kinetic energy is equal to the mechanical energy, so:

$\frac{1}{2}mv^2 = 1.275m$

$v = \sqrt{2.55} = 1.6\ {}^{m}/_{s}$

c) The initial horizontal speed is calculated in part b) and is v_x = 1.6 m/s

For the vertical speed we first calculate the time of the free fall from:

$\frac{1}{2}9.81t^2 = 1.0$

$t = \sqrt{\frac{2.0}{9.81}} = 0.45\ s$

Then the vertical speed is:

$v_y = 0.45 * 9.81 = 4.43\ {}^{m}/_{s}$

The total speed is then:

$v = \sqrt{v_x^2 + v_y^2} = 4.7\ {}^{m}/_{s}$