UNIVERSITÄT LEIPZIG

Mock Exam
"Experimental Physics I" - IPSP
Prof. Dr. R. Seidel
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Please don't forget to write down your name and matriculation number on every sheet. Also use a new sheet for each task and sort them accordingly.

We wish you good luck!

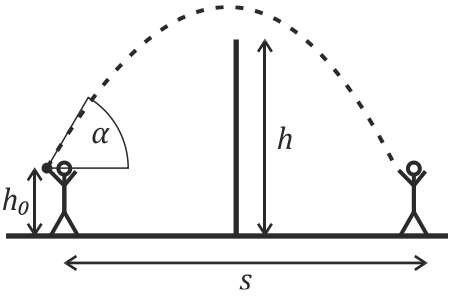
Full Name, Matriculation number:								
Points	T1	T2	T3	T4	T5	T6	T7	T8

Potentially useful quantities/constants

Gravitational acceleration	$g \approx 9.81\ \mathrm{m/s^2}$
Gravitational constant	$G \approx 7 \cdot 10^{-11}\ \mathrm{m^3 kg^{-1}\ s^{-2}}$
Mass of the earth	$M_\mathrm{E} \approx 6 \cdot 10^{24}\ \mathrm{kg}$
Radius of the earth	$R_\mathrm{E} \approx 6400\ \mathrm{km}$
Speed of sound in air	$v = 330\ \mathrm{m/s}$
Density of air	$\rho = 1.20\ \mathrm{kg/m^3}$

Task 1: $(\mathbf{2+2\ Points})$

A child wants to throw a ball over a fence with a height of $h = 3\ \mathrm{m}$. It can throw the ball with an initial speed of $v_0 = 7.5\ \mathrm{m/s}$ at an angle $\alpha = 60°$ with respect to the ground. The starting point of the throw is $h_0 = 1\ \mathrm{m}$ above the ground.



a) Calculate if the child can throw the ball high enough, to get it over the fence.

b) At the other side, another child is trying to catch the ball. At which distance to the first child can the ball be caught at $h_{catch} = 1\ \mathrm{m}$ above the ground?

Note: Neglect any friction.

Task 2: $(\mathbf{2+2\ Points})$

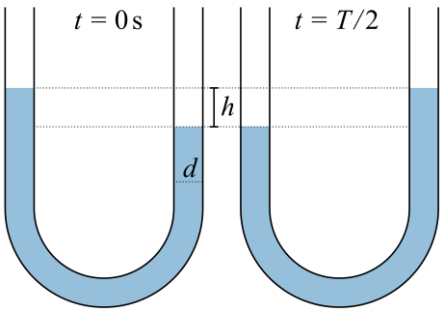
You are sitting in a boat floating on a very small pond.

a) You take the steel anchor out of the boat and drop it into the water. The anchor then sinks to the ground. Does the water level in the pond slightly rise or fall, or remain the same? Explain your answer. (Maximum of 3 sentences)

b) Now you also throw away your wooden paddles, which float on the water. Does the water level in the pond slightly rise or fall, or remain the same? Explain your answer. (Maximum of 3 sentences)

Task 3: $(\mathbf{2+1+1\ Points})$

A U-shaped hollow glass tube with circular cross-section and diameter of $d = 1\ \mathrm{cm}$ is filled with 30 grams of water. You gently shake it and the water level starts to oscillate up and down (see figure). The amplitude between highest and lowest water level is $h = 4\ \mathrm{cm}$. Friction can be neglected.



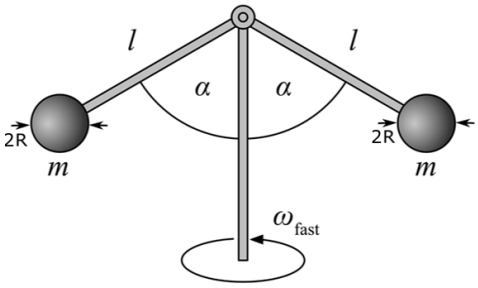
a) Derive an expression for the equation of motion ($x(t)$) of the water level.

b) Calculate the oscillation frequency f of the water level.

c) Calculate the maximum speed v_{max} of the water level.

Task 4: $(3 + 1$ Points$)$

Given is a centrifugal governor invented by James Watt (see figure). The length of the arms is $l = 15\,\mathrm{cm}$ and the mass of each of the spheres is $m = 1\,\mathrm{kg}$. The arms can be considered massless. Initially, the centrifugal governor rotates moderately fast and the angle between the arms and the centre beam is $\alpha_{\mathrm{fast}} = 60°$.



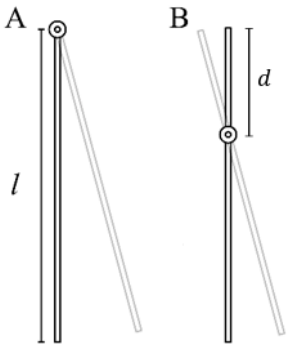
a) Calculate the angular rotation speed ω_{fast} for the angle α_{fast}.

Now the governor is at rest and the spheres are at their lowest position where they touch the central axes. Then the centrifugal governor starts to rotate with a lower, critical rotation speed ω_{crit} at which the spheres start to "lift off" due to the small but none-negligible radius of the spheres (i.e. $R \ll l$). All rotation speeds slower than ω_{crit} result in no lift-off of the spheres.

b) Find the (non-zero) critical rotation speed ω_{crit}.

Task 5: $(4 + 2 + 2$ Points$)$

A thin rod of length $l = 1.8\,\mathrm{m}$ and mass $m_R = 460\,\mathrm{g}$ is used as a physical pendulum (see figure A).



a) The pendulum is initially at rest. At $t = 0$ it is hit elastically by a horizontally flying plastic ball (mass m_B, speed v_B) at its lower end. The plastic ball is reflected horizontally. What is the angular amplitude with which the pendulum is oscillating after the collision? Name the two conservation laws that are required to solve this problem.

b) Calculate the period T, when the rod in A oscillates around a horizontal axis fixed at one end. Assume a small angular amplitude.

c) Now consider the configuration in Figure B: For which distance d between the upper end of the rod and the horizontal axis will the period T_{min} be minimal?

Task 6: $(\mathbf{3 + 1 + 2\ Points})$

A new satellite is shot into a circular orbit around earth. It is supposed to travel around earth every 48 hours.

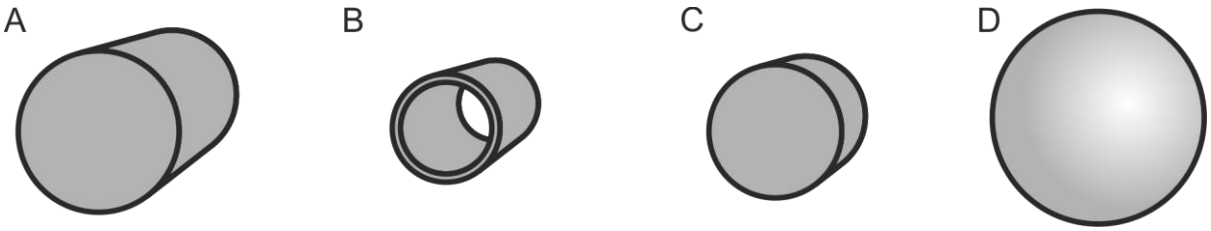
a) Calculate the height of the satellite above the ground and its speed along its orbit.

Due to the new satellite, an older version traveling on the same orbit has become obsolete and is supposed to be taken down. The satellite's speed is therefore reduced instantaneously but without changing the direction of travel. On the new orbit the satellite is supposed to enter earth's atmosphere and burn out.

b) Make a sketch of the new orbit. What type of orbit is the satellite on?

c) How much does the old satellite at least need to be slowed down, such that it just enters earth's atmosphere (100km above ground) and burns out?

Task 7: $(\mathbf{4\ Points})$



Three cylindrical objects (Figure A - C) and a sphere (D) of unknown masses and sizes are rolling down an inclined plane. Assuming they all start at the same time, sort them by the order at which they arrive at the bottom. Explain your answer briefly.

Note: The mechanical energy is conserved.

Task 8: $(\mathbf{2 + 1 + 1\ Points})$

How large is the oscillation amplitude of a sound wave in air and the maximum velocity of the oscillating particles for a frequency $f = 1\ \mathrm{kHz}$

a) at the hearing threshold (0 dB)?

b) at the absolute threshold of pain (130 dB)?

c) At which speed does an observer need to travel towards the source of the wave in order to perceive the sound higher by a whole tone ($f' = 1.12246 \cdot f$)?