EXPERIMENTAL PHYSICS 1

EXERCISE 5

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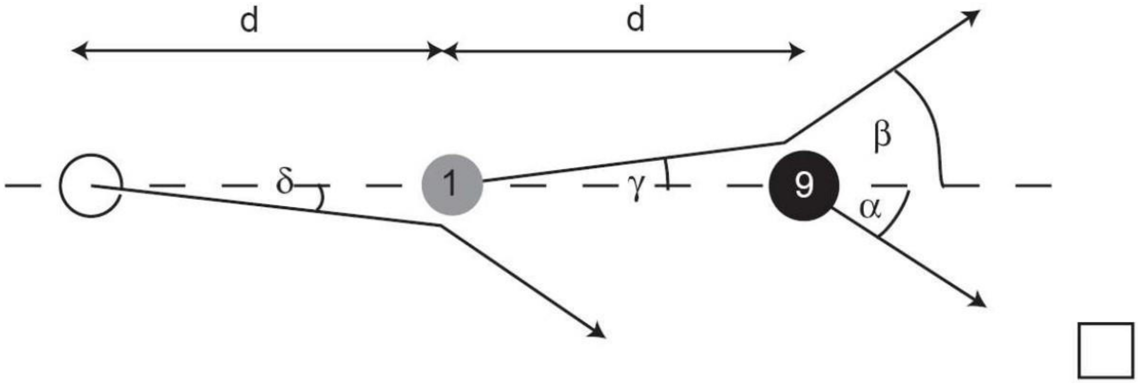
Problem 1: Billiard Collision "9-Ball" **4 Points**

Three billiard balls lie on a straight line with the distance d between the balls each. The first (white) ball is shot, hits the second ball (No. 1) which in turn strikes the third (No. 9). For the last ball (No. 9) to be pocketed the angle must have a value $\alpha = 30° \pm 2°$. The player decides to shoot the first ball under an angle $\delta = 1°$ $(d = 40 \text{ cm})$. Is this successful?



(Hints. The angles δ and γ are very small such that the following approximation can be used: $\gamma' \cong \sin\gamma$ and $\delta' \cong \sin\delta$. All angles have to be calculated in radians. Neglect friction forces.)

Problem 2: 3D Motion, Bottle out of Train $\mathbf{2+2+2}$ Points

A bottle is thrown horizontally from a train at a right angle to the train's velocity. It hits the ground at a point that is 5m below, 10m afar (in perpendicular direction) and 25m afar (in the direction along the velocity of the train) from the point of throw. (Air resistance is neglected)

a. Calculate the speed of the train,
b. the initial velocity of the bottle,
c. the velocity of the bottle as it hits the ground.

Problem 3: Galilei transformation **3** Points

In an inertial system S a lamp is shining at coordinates $(x, y, z) = (940\text{m}, 236\text{m}, 204\text{m})$ and time $t = 773\text{s}$. What coordinates will someone prescribe to the lamp who passes by the system S at a constant speed of $(v_x, v_y, v_z) = \left(2\frac{m}{s}, 1\frac{m}{s}, 0\right)$? ?

Problem 4: Galilean Invariance **3** Points

The "Laplace operator" is a mathematical operator that you will encounter consistently throughout your physics studies. The operator simply takes the second order partial derivatives of a function and adds them up: $\Delta f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2}$. Show that for an arbitrary function $f(x, t)$ the operator is invariant under Galilean transformation i.e. it preserves its form. (It is sufficient to show the invariance for only one coordinate component: $\Delta f = \frac{\partial^2 f}{\partial x^2}$)

(Hints. Write $f(x, t)$ in terms of $f(x', t') = f(x - vt, t)$ and perform the derivatives)

Task to think about

How must a well working safety hat be designed and constructed in order to provide maximum protection in case of a stone dropping on the wearers head?