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Mechanik (Theoretische Physik 1)

Sommersemester 2018

Abgabe bis Freitag, 11.05.18, 12:00 neben PH 3218.

Übungsblatt Nr. 5 Dieses Blatt wird in den Übungen vom 14.05. - 18.05.18 besprochen.

Aufgabe 1:
Oktoberfest in Space **3 Punkte**

At $t = 0$, three people stand on a Devil's wheel that rotates counterclockwise with angular speed ω in the absence of gravity. Rosi (person 1) has lifted Wasti (person 2), both separated from Maxi (person 3), who starts to feel uneasy. Considering an inertial reference frame whose origin coincides with the center of the wheel, Rosi (person 1) and Wasti (person 2) are located at $(x, y) = (0, -R)$ at $t = 0$, while at that instant Maxi (person 3) is located at $(x, y) = (R, 0)$. The time $t = 0$ is also when Rosi throws Wasti in the direction parallel to the $(1/2, \sqrt{3}/2)$ vector, with the aim of hitting Maxi.

1. What is the speed at which Wasti (person 2) has to be thrown, so as to hit Maxi (person 3) off the wheel? How much has the wheel rotated when the impact takes place?

2. What are the differential equations for the trajectory of Wasti (person 2) in a reference frame that rotates with the wheel? Solve these (either directly or using the results from part 1.) given the boundary conditions implied above.

Aufgabe 2:
The Magnetic Field under Parity transformation **2.5 Punkte**

Consider a system in which a particle of charge q is moving with velocity $\mathbf{v}$ in the magnetic field generated by an electric current $\mathbf{j}$ going through a loop of wire.

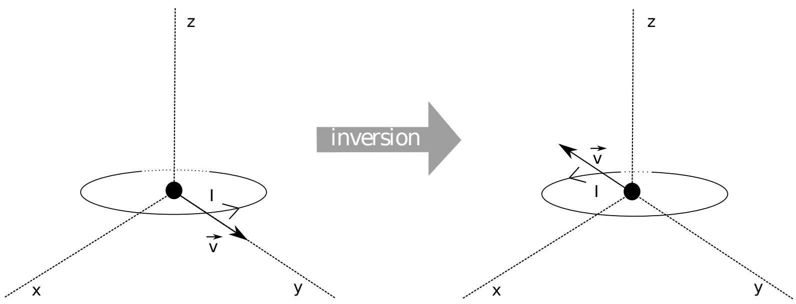

Abbildung 1: The system and its point reflection (inversion).

1. Prove graphically that performing a point reflection with respect to the origin (see Figure) is equivalent to performing a reflection with respect to the xz-plane plus a rotation of π around the y-axis. Does the field $\mathbf{B}$ behave as $\mathbf{v}$ and the Lorentz force?

2. Prove that the aforementioned transformations are equivalent by composing them from matrix representations of the reflections and rotations.

Aufgabe 3:
The Levi-Civita symbol **2 Punkte**

The Levi-Civita symbol ϵ_{ijk} is a completely antisymmetric tensor, defined by the relation $\epsilon_{123} = 1$. All the other values follow from its anti-symmetry in the indices $\{ijk\}$. A convenient way to express the components a vector product of two vectors is:

$$(\mathbf{a} \times \mathbf{b})_i = \epsilon_{ijk} a_j b_k$$

Using the latter, prove the following relations:

1. $(\mathbf{a} \times \mathbf{b})^2 = a^2 b^2 - (\mathbf{a} \cdot \mathbf{b})^2$
2. $(\mathbf{a} \times \mathbf{b}) \cdot \big[(\mathbf{b} \times \mathbf{c}) \times (\mathbf{c} \times \mathbf{a})\big] = \big[\mathbf{a} \cdot (\mathbf{b} \times \mathbf{c})\big]^2$

Hint: Use the following useful relation: $\epsilon_{ijk}\epsilon_{ilm} = \delta_{jl}\delta_{km} - \delta_{jm}\delta_{kl}$ where Einstein's sum convention is implied.

Aufgabe 4:
A Journey across Germany - The Coriolis Force **2.5 Punkte**

A train is travelling from Munich to Hamburg on a path that can be thought to be on a meridian. The railroads workers notice that one of the rails gets worn out more quickly than the other. Why? Which one?
Consider a train coach that weighs 500 t travelling at a constant velocity of 200 km/h. Knowing that:

$$\theta_{\text{Munich}} = 48.14^\circ\,,$$
$$\theta_{\text{Hamburg}} = 53.55^\circ\,,$$
$$|\omega_{\text{Earth}}| = 7.3 \cdot 10^{-5}\,\text{rad/s}\,,$$

where the angles refer to the geographic latitude,

1. draw a plot of the norm of the Coriolis force from Munich to Hamburg as a function of the latitude,
2. quantify the effect by comparing it to the other main force involved in the system, i.e. the weight of the coach.