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Didactic Example of Physics Applied to Jurisprudence

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Abstract

The teaching of physics is a very important social task even if it concerns only basic physics.
The case of a real trial in which a bad knowledge of physics laws led a monocratic judge to issue a judgment based on erroneous physical conclusions is reported. The relevant thing is that the monocratic judge was misled by a technical report prepared by an alleged expert.
In the trial, the defendant, Mr. D.S. (Defendant for Slander), was accused of slander; in particular, Mr. D.S. would have falsely accused, by means of a summons, his neighbor, Mr. O.P. (Offended Party), of having caused him a damage for which he would have demanded undue compensation. The harm would have been caused by external plaster pieces that would have detached from mr. O.P.'s property and would have reached mr. D.S. in his garden, more than a meter away from the O.P.'s building facade, injuring him in his head. The technical report should have contained the calculations or the estimate of the possible trajectories of the detached external plaster pieces, while it expresses only qualitative conclusions based on totally wrong physical considerations.
The analysis of the errors can be a useful help to identify some physics concepts that could be misunderstood by students and that should be explored in depth. In addition, this article could be a useful and interesting reading for students of basic physics courses so that they can appreciate even more the real importance of what they study and can better understand the principles of basic physics.
Keywords: *Projectile motion, Physics Teaching, Restitution Coefficients, Action-Reaction Pair.*

1. Introduction

In this article, the case of a real trial in which a bad knowledge of physics laws led a monocratic judge to issue a judgment based on erroneous physical conclusions is reported. The monocratic judge was misled by a technical report prepared by an alleged expert. Both the technical report and the judgment are parts of official legal documents published and filed at the court of Nola - Italy (sentence n. 1010/2020 issued on June the 15th 2020 at the Nola Court - Single Judge of first instance in monocratic composition - and filed on June the 19th 2020). In the trial, the defendant, Mr. D.S. (Defendant for Slander), was accused of slander; in particular, Mr. D.S. would have falsely accused, by means of a summons, his neighbor, Mr. O.P. (Offended Party), of having caused him a damage for which he would have demanded undue compensation. The harm would have been caused by an external plaster piece that would have detached from Mr. O.P.'s property and would have reached Mr. D.S. in his garden, more than a meter away from the O.P.'s building facade, injuring him in his head.
In order to understand the dispute and the physical problem, in Fig. 1 the physical situation is represented. Furthermore, in order to highlight the errors contained in the technical report, the physical solution of the problem, proposed by the authors, will be presented in the next section.

2. The physical solution

On the day of the alleged accident there was no wind and therefore its possible effects can be neglected. Furthermore, friction with air can be neglected, because in any case it has a braking effect and therefore a shortening of the horizontal range. Therefore, the only force acting on an external plaster piece during its motion is the weight force, a conservative force. The equations of motion of the plaster piece will be:

1) $\vec{F_g} = \mathrm{m}\vec{g} = \mathrm{m}\vec{a_c}$, where $\vec{a_c}$ is the center of mass acceleration.
2) $\vec{\tau_e} = 0 = I_u \frac{d\vec{\omega}}{dt}$, where $\vec{\tau_e} = 0$ is the $\vec{F_g}$ moment relative to the center of mass *C*, I_u is the moment of inertia relative to an axis *u* passing through *C*, and $\vec{\omega}$ is the angular velocity around the *u* axis.

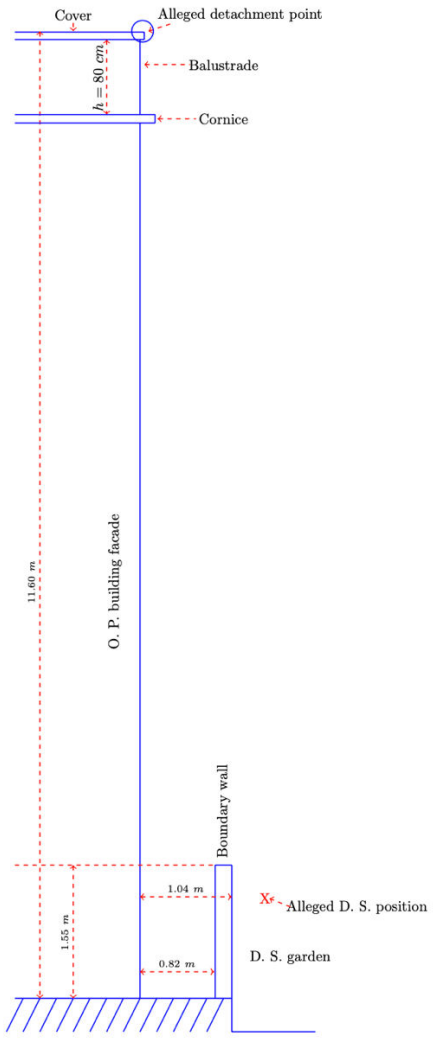

Fig. 1. P.O.'s building profile at the minimum distance from the boundary wall. A red X indicates the point where Mr. D.S. would have been hit by the plaster piece, point which is not on the same plane. This point is horizontally well over 1.30 m from the building wall from which the plaster pieces would have come off.

Equation 1) describes the motion of the center of mass *C*, that is where the plaster pieces may arrive, while equation 2) rotations about the center of mass *C*, and in particular tells us that the rotation speed remains constant. In order to establish if external plaster pieces might have reached mr. D.S. in his garden, one has to consider only equation 1), which allows to estimate the distance that they might have travelled.

In Fig.2, all calculations about the center of mass motion are reported. In particular, a detached external plaster piece, subject only to the weight force, travels, with a projectile motion, until it collides with the cornice. Taking a very conservative assumption, it will be assumed that the external plaster piece hits a point of the cornice other than the foot of the perpendicular to the point of contact (that is a point of coordinate other then $x_i = \delta$ in Fig. 2). In that case, the plaster piece must have, at the moment of detachment, a small horizontal component of the velocity, v_{0x}, that can be determined kinematically according to the point of collision coordinate.
During the collision, the force of reaction due to the plane of the cornice, an impulsive force of contact, acts. The effect of the collision is described by Newton's coefficients of restitution (COR) [1,2]. After the collision, the plaster resumes its motion of a projectile subject only to the weight force.

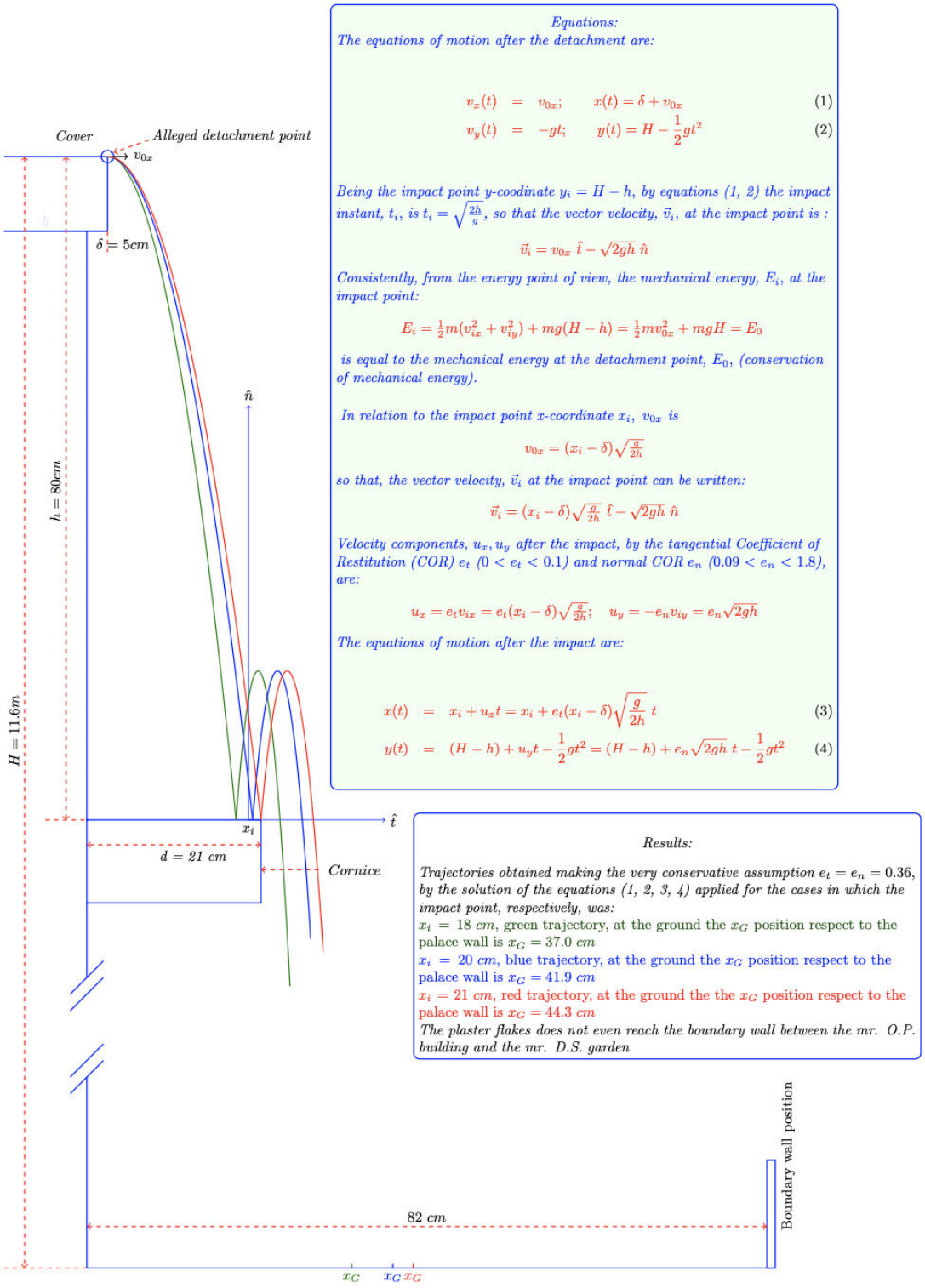

Fig. 2. Physical solution.

3. The technical report

Contrary to the solution of the equations of motion, the technical report states that the external plaster piece may have reached the garden of Mr. D.S. and they may have hit him. In the following, the contents of the technical report in quotes and in italics style is reported.

"…Once the detachment point of the material "(reported by a circle in Fig. 1)*" has been identified, let's analyze the possible trajectories traced by the material after detachment… In all cases, the cornice is involved, which constitutes not only the main obstacle to the falling stones but is also the one that determines the possible trajectories of the stones themselves, according to their masses and to their geometric shapes. The height of fall does not matter, …, the fundamental thing is the point of application of the reaction force, which is the force action that the cornice exerts on the stone. Therefore, in the collision between stone and cornice, a system of forces is thus generated, all applied to the mass of the falling stones* "(see Fig. 3)*". Of course, for the trajectories it is necessary to know not only the system of applied forces, but also the mass and geometry of the individual stones that hit the cornice. … The trajectories of the fragments, on the other hand, are characterized by the set of points of application of the resultant of all the forces acting on the fragments throughout the path.*

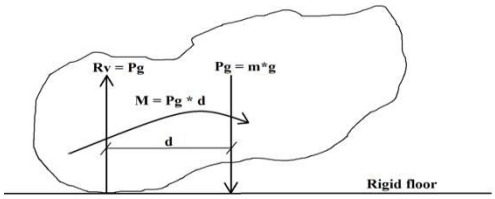

Fig. 3. Scheme of forces acting on a rigid plane according to the technical report.

…the hypothesis of the discovery of materials within D.S.'s lot, appears possible and legitimate, because there is not only a system of forces acting on the bodies (stones) but also of moment solicitation that inevitably cause the onset of rotation of the mass of bodies. In fact, in our case, in addition to the gravitational force applied to the center of gravity of the mass, there is also another force that arises as a reaction to the gravitational one, and it is the force exerted by the cornice on the mass of material falling from above. The latter is equal and opposite to gravitation, and if applied in a point other than the barycenter of the mass because it is a geometrically non-definable body with uncertain shapes and of non-homogeneous material. In the statics of bodies, two forces of opposite sense which maintain the same direction, the same intensity, but which are applied in different points, give rise to a couple that gives the movement of the stone a rotary motion '(Fig. 3)'. And it is this couple of forces that, in my opinion, determined the removal of the stones until they reached the D.S.'s property."

According to the technical report, the force due to the cornice, $\mathbf{R_v}$, and the gravitational force, $\mathbf{F_g}$, are a third-law force pair and therefore are equal in magnitude and opposite in direction. If this were the case, the resultant of the forces acting on the external plaster would be zero and therefore the plaster would have no acceleration ($\mathbf{F_g}+\mathbf{R_v} = 0 = m\mathbf{a}$). Evidently, the $\mathbf{R_v}$ and $\mathbf{F_g}$ forces applied to the stones (external plaster pieces) are not a third-law force pair, because forces of third-law force pair always act on different bodies [3]; furthermore, $\mathbf{R_v}$ is a contact force, acting only during the contact, while $\mathbf{F_g}$ is an action-at-a-distance force always acting.

For the same reasons, $\mathbf{F_g}$ and $\mathbf{R_v}$ cannot constitute a couple of forces [4, 5], so that there is no torque acting on an external plaster piece during its motion.

"The transformation of the potential energy into the kinematic one also gives the stones an increase in forces and motion that allows them to reach even significant distances from the point of fall."

Forces determine the energy of a system and not the other way around. In the transformation of potential energy into kinetic energy there is no increase in forces.

"Before finishing the technical report, I invite anyone to make the experience of dropping a small stone from his hand and checking its distance reached after the fall, he will notice that in some cases it even exceeds one meter. All this happens precisely because the mass of the stone, geometry, strength and stiffness come into play, as well as the stresses deriving from the application of the system of forces which are: Pg, Rv and M."

We leave the relevant considerations to the attentive readers.

4. Conclusion

In this article the case of a real trial, in which a bad knowledge of the physics laws led a monocratic judge to issue a judgment based on erroneous physical conclusions, has been analyzed (sentence n. 1010/2020 issued on June the 15th 2020 at the Nola Court - Single Judge of first instance in monocratic composition - and filed on June the 19th 2020). The relevant thing is that the monocratic judge was misled by a technical report prepared by an alleged expert. Essentially, in the technical report it is stated, mistakenly, that the horizontal range of the center of mass motion of an external plaster piece detached from a building is lengthened by the effects of a (non-existent) couple of forces and by an additional force resulting from the continuous transformation of potential and kinetic energy into a force. The technical report contains only opinions and imaginative, subjective interpretations, among other things erroneous, of some physical and non-physical laws; the contained conclusions are not the result of any mathematical model (and could not have been given the erroneous physical setting) and do not express any verifiable numerical data.

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