Pleasure as a teaching tool

Héctor G. Riveros
Instituto de Física, UNAM, A. P. 20-364, CP 01000, México D. F.

E-mail: riveros@fisica.unam.mx

(Received 26 August 2011; accepted 18 October 2011)

Abstract

A feeling of pleasure is naturally associated to the process of understanding new things. This association is particularly important in the formation of students who are trying to find their vocation. Moreover, this kind of pleasure is probably the principal motivation of scientific work (if pleasure can be called work), and I will try to demonstrate this thesis. In the conference I will present some demonstrations to create an environment in which the spectators will be able to understand what they observe. If they understand by themselves the demonstration, they will experience the pleasure of understanding. I will use demonstrations and questions to find out quickly the student misconceptions (without generating hard feelings), allowing us to dedicate more time to clarify them. Human motivations range from love to hate, and from pain to pleasure: as teachers we can choose which motivations we employ.

Keywords: Reasoning, Understanding, Demonstration, Discrepant events.

Resumen

Una sensación de placer está naturalmente asociada al proceso de entender algo nuevo. Esta asociación es particularmente importante en la formación de estudiantes en la etapa de encontrar su vocación. Esta sensación de placer es probablemente la principal motivación para el trabajo científico (si al placer se le puede llamar trabajo), y trataré de demostrar esta tesis. En la plática se presentan algunas demostraciones para crear un ambiente propicio para que los presentes puedan entender lo que observan. Si entienden la demostración sin ayuda experimentaran el placer de entender. Se muestra el uso de demostraciones y preguntas para encontrar rápidamente los preconceptos estudiantiles (sin provocar resentimientos), lo que permite tener más tiempo para enseñar los temas difíciles. Las motivaciones humanas van del amor al odio, y del dolor al placer, como profesores podemos escoger que motivaciones implementar.

Palabras clave: Razonamiento, Entender, Demostraciones, Eventos discrepantes

PACS: 01.40.E-, 01.40.gb, 01.40.My **ISSN 1870-9095**

I. INTRODUCTION

It is generally thought that scientific work is very difficult and reserved for exceptional minds. The way we teachers Physics, Chemistry and Mathematics helps the children to hate them. But over the centuries, science has been cultivated for the pleasure it provides to understand the why of things. We should share this sense of pleasure, with the rest of the society in which we live. In the beginning all the sciences began as pleasant pastimes; most people consider working in science as difficult but really is a pleasure for anyone who has a vocation to do so. It is this aspect that we should disseminate to as science is a part of modern life. This is particularly important for the formation of children and young people trying to find his vocation. But we must note that what an adult means to understand is different from what a child thinks, for example, when an adult sees a propeller turning at the end of a stick he explained in terms of vibrations and waves phases and when a child observes the same phenomenon and asks why he really want to understand is what I have to do to turn the propeller

II. MENTAL CONNECTIONS WE CALL LEARNING

Before teaching we need to have a clear idea of the purpose of teaching the topic to determine what to teach and how to teach, or how to evaluate, how to use or generate materials, etc. The traditional teacher gives his class as he received it, using preferably chalk and the board. The universities give refresher courses for teachers in that they are received weapons to improve their classes. Moreover we are generating information at a pace unprecedented. What matters now does not know a lot of data, it is managing information. The existence of computers changed the way we work, and therefore it is necessary to use them in the classroom. But every teacher needs to adapt new teaching skills and new technologies to the way he teach. Teaching physics induces the pleasures of reasoning and thinking is an art.

Teachers and students have difficulty connecting theory to real life. Teachers receive training about the different theories on the teaching-learning process or courses about physics topics; but have trouble applying those ideas in their classrooms. Similarly, students are given many courses in physics, but have trouble to design an experiment aimed at solving a problem.

The problem of education authorities, it is to improve the teaching-learning process, taking into account the potential of students, teachers and new teaching resources. The debate on how to update the teachers presented two extremes: those who believe it is essential to know courses related to the teaching-learning process, and those who think that knowing physics is essential, since you cannot teach what you don't know. I know very few courses that combine both points of view

III. LEARNING FROM THE PAST

Several decades ago it was thought that combining the best educators with the best scientists could design the course to solve the problem; we have survived several of these projects with the surprising result that we are as we started. The Physics Today [1] presents an analysis of the evolution of textbooks in the last hundred years and shows that educational innovations have a certain frequency, shifting the responsibility from teacher to student or vice versa. Research on teaching (PER) has made valuable contributions, but they are not always universally applied. We all remember some teachers that left a permanent imprint on our lives, because their teachings change us, for better or for worse. A human change by the love of pleasure or fear of pain. Being a teacher is a big responsibility, according how gives his class; each teacher chooses how he wants to be remembered by his students.

Generally, the teacher's problem is how to teach the topics of the course program taught, knowing the time and resources. The debate about teaching has many aspects, from those who wants to teach the basic principles to draw all the consequences to those who try to induce from experimental work the laws of science. Some also prefer to rely on history of science to motivate the student, or applications solving "real life" problems.

So far, there is not a technique that works with all members of a group of students, what works with some will not satisfy others. The problem of teaching a subject is a problem of research on teaching. Defining why the subject is taught helps to decide the evaluation, and possible teaching strategies. If we can convince the student that they need this knowledge for his professional life, you get a different motivation from of studying to pass, often prevailing in students. The other half of the problem is to find out what they already know the subject so as not to bore them with repetitions, to correct errors or to supplement their knowledge.

The history of physics help with examples and the applications in their profession or in daily life make it relevant to the student. Defining the evaluation in each subject before teaching, helps choose the best procedure for teaching. Only when something interests us, we make the mental connections that allow us to keep in memory without effort, and this is what we call learning. An enjoyable activity for teachers is to design demonstrations and experiments with materials available in their labs, when they discover that it is possible to predict and optimize a demonstration, usually with simple models of the situation. The theoretical model used to fix the experimental conditions, allows a comprehensive knowledge of physics. In short: Teaching Physics introduces to the pleasures of reason and the Art of Thinking. Teaching an Art is an art and therefore enjoyable.

IV. DISCREPANT EVENTS PROMOTE REASONING

Some physics demonstration can be considered “magic”, because are very discrepant events [2, 3].

Demonstrations, experiments or questions can be used to demonstrate that understanding the why of things is pleasant. And this pleasure is the motivator of the researcher, as an artist, takes pleasure in his art. When we research topics that interest us, simply we have better ideas all the time because we are thinking about the subject without effort on our part. But actions speak louder: so we will describe some activities that can be developed in class, as an example of materials:

Snake below a top. With the top spinning, the snake moves below the top. Answer: there is a magnet inside the top. The magnetic field goes down inside the iron rod used as axis. The snake (iron) is attracted to the axis and by friction moves along its edges.

Sound from a corrugated tube turning in the air. Answer: the air inside the tube flows because the air near to the extreme rotating is ejected by the “centrifugal” force. If the flow is turbulent, the inside corrugations produces changes in pressure, with period T, related to its speed and width of the corrugations. When the wavelength of the sound matches a resonance mode, it is amplified so you can hear it.

Drop together, a ping-pong ball on a hard rubber ball. This demonstration surprises the audience because the ping-pong ball goes up to 5-6 times the height of the fall. To understand this we should consider two other collisions. The collision between a light and a heavy ball at rest, shows that the lightweight ball reverses its velocity. If the collision were completely elastic, the magnitude of the velocity be the same. A ball bouncing elastically on Earth would maintain the same height If a heavy ball hits a light ball at rest, this comes with double speed. We can understand this changing the system of reference to the heavy ball. In the case that both carry the same speed but opposite directions, one can calculate that the speed of light bounce of the ball is three times higher. This is nine times the original kinetic energy, so if the collision were elastic the light ball should go up to 9 times the original height. That does not rise so much tells us that the shock is not completely elastic. This is the time to discuss the dangers of hitting the fat student in the schoolyard, or a heavy truck on the road.

Crash data reported in Popular Science (October 1992, p. 60), a Saab 9000 car with an speed of 35mph hits a solid rod at t=0, it's speed is zero at time 0.09s and a total deformation of 30"; the driver with a seat belt stops in 0.12sec. From this we calculate a car deceleration of $166m/s^2$ and a driver deceleration of $125m/s^2$. This deceleration justifies the need to use seat belts. Although the speed is relatively small (57km/h) the average deceleration during the collision becomes 17 times the acceleration of gravity. That is if the car weighs a 1ton, the force on the car is of 17tons. Before seeing these numbers, I always thought that in the event of a collision my hands on the board could stop the body, but it is clear that I have not enough strength to support 17 times my weight. The seat belt increases the duration of the collision (to 0.12s), reducing to 13 times the acceleration of gravity the acceleration needed. This dramatically increases the chances of surviving the crash.

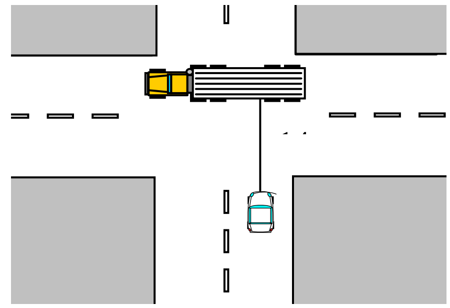

FIGURE 1. A truck stops suddenly in front of a car 14m away. The driver should apply the brakes or turn the wheel to avoid the truck.

V. PHYSICS AND REAL LIFE

Should one Stop or Turn to Avoid an Automobile Collision?

It is quite difficult to find examples of physics related to the daily life. When we asked this question to the public in many talks, about 80% of the audience said that they will turn to avoid the collision. So later, when we show that it is always better to apply the brakes, they will remember the talk because that can save their life. So let us be more specific about the question:

A man driving an automobile at a speed of 54km/h (15m/s) suddenly found a big truck stopped at an intersection 14meters away. To avoid hitting the truck, the man must either apply the brakes in order to try stop in a forward direction, or turn to avoid the truck, or he can also do both. What is the wisest decision given a certain coefficient of friction μ between tires and road surface?.

The frictional force should be used to reduce the speed in a forward direction, or to turn along the circle of minimum radius R, without reducing speed. Also a combination of both procedures could be used.

We need to remember that the static frictional force is always between zero and its maximum value, and it tries to avoid the slipping of the points in contact. For a car tire the static friction coefficient is about $\mu=0.8$.

During braking the energy is dissipated. On the other hand, the energy is conserved while turning along a circle (without braking), if the same speed is maintained. Three choices are open: (1) to keep on straight ahead and apply the brakes fully, (2) to turn in a circular path, without braking, using all the available friction force to produce a centripetal acceleration with the minimum radius R, (3) to choose some combination of steering and braking, driving along some intermediate path.

If we try to turn with a radius less than R, the frictional force will not be enough and the tires will slip on the road, or a rollover will be produced, depending on the height of the center of mass of the vehicle. It is very difficult to steer a skidding car. Cars with the antilock braking system ABS avoids slipping of the tires by reducing the braking force on any tire near to slipping, and consequently the turning reduces automatically the maximum braking force. A four-wheel system is intended to keep all the wheels rolling during panic braking, in order to prevent yawing and to allow steering throughout the emergency. The combination of stopping and steering is intended to help the driver to avoid mobile and fixed obstacles. The National Highway Traffic Safety Administration NHTSA [4] says: "The effect, however, is not inevitably for the better. ABS confers the capability to steer a car while slamming on the brakes, but the average driver in a panic situation might not always use this capability to advantage, and might even steer the car into a worse situation than the one which the driver was trying to avoid". And "The tests confirmed that ABS was highly effective in preventing yawing and allowing the driver to steer the car during panic braking. Stopping distances decreased substantially with four-wheel ABS on wet surfaces, but decreased only slightly on dry pavement and increased considerably on gravel". They only forget to tell that turning only does not reduce the speed of the vehicle. Remember the stopping distance is about the same with or without ABS, on dry pavement (and remember that Mexican highways frequently have some gravel!).

One must remember that the frictional force acts against the slipping of the portion of the tire that is in contact with the floor. The instantaneous friction force depends on the velocity of the skidding car and the angular velocity of each tire. If the car is without ABS, by braking we can lock the tires losing any control about the direction of the skidding. Any difference in the friction acting on the wheels will produce a torque about the center of mass of the car.

From Newton's Second Law we know that in order to produce a uniform circular movement we need a centripetal force constant in magnitude, and for a car moving in a circle that force comes from the friction with the road. The minimum radius R of the circular path of a car of mass m and velocity v is produced when the maximum value of the frictional force (μmg) is equal to the magnitude of the centripetal force:

$$\frac{mv^2}{R} = \mu mg \qquad \text{Then} \qquad R= \frac{v^2}{\mu g}. \tag{1}$$

If we apply the brakes the maximum deceleration is μg, and the minimum braking distance x is:

$$x = \frac{v^2}{2a} = \frac{v^2}{2\,\mu\, g} = R/2= (15)^2/(2x0.8x9.8)= 14\text{m}. \tag{2}$$

So, the braking distance is half the minimum radius R.

Using the data one finds: R=28m and x=14m. Therefore, by braking the car we can avoid the collision, while by turning the maximum deviation is only 1.7m (12% R), and the collision occurs at the full speed of 15m/s. Fig. (2) shows that both paths are quite close to each other.

If the initial distance is larger than 14m, by braking, we can stop before impact without any trouble. If the initial distance is less than 14m, by braking only the speed at the instant of the collision is reduced and therefore so is the kinetic energy to be dissipated in the deformation of the car and truck. By only steering, the collision will need to dissipate all the initial kinetic energy with about 0.75m of damage to the front of the car[2]. Any path in between produces more damage than braking only.

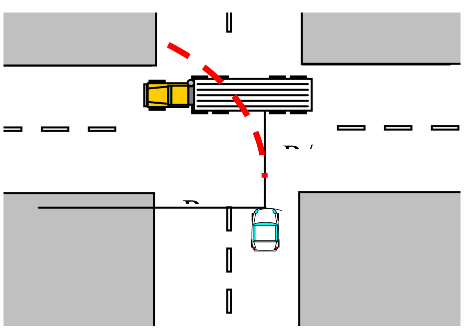

FIGURE 2. The minimum radius for turning is always twice the braking distance. The maximum deviation is only 12% of the braking distance, so braking is the best choice.

The driver can choose an intermediate path such that divides equally the available friction force between the centripetal force and the braking force. Then both will be 0.71μmg, and the radius of curvature is $1.41R_0$ (40m). Assuming constant the braking force the arc length is 19.8m, the arc length to the truck is 14.3m so the car needs 5 more meters to avoid hitting the truck. Using ABS brakes, the arc length traveled is slightly reduced as the factor in the braking force increases from 0.71 to 1 as the centripetal force reduces along with the speed squared. To be more realistic to the calculated distances we need to add the distance traveled by the car before the driver decides what to do or reaction time.

This is an example illustrating that physics is useful in real life if we analyze situations before they happen because during a collision things happen so fast, that we don't have time to think, we need to react. The human tendency is to turn first (according with the answers given in many talks), so now you know that braking is the best option in any case.

VI. CONCLUSIONS

These are a few examples of what can be done with the information available, or common objects around us. Physics is present in our daily activities, paying attention will find it. What is important is not memorizing equations, but to capture the pleasure produced by understanding the why of things. In the profession, choosing a theme of work, it is important that inspire us, to work with great pleasure, we will find that this increases our efficiency, but above all, the work becomes a pleasure. We all remember a few very good teachers, but also remember the bad. Hopefully we will remembered in the good.

REFERENCES

[1] Holbrow, C., *Archaelogy of a bookstack: some major introductory physics texts of the last 150 years,* Physics Today **52**, 50-56 (1999).

[2] Riveros, H. G., *The science behind magic tricks,* Phys. Educ. **46**, 9-10 (2011).

[3] Riveros, H. G., *Was it magic or was it science?*, Phys. Educ. **46**, 142-143 (2011).

[4] Kahane, C. J., NHTSA Report Number DOT HS 808 206 (1994).