INNOVATIVE IDEAS IN PHYSICS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT: The education in contemporary society, as particular case in physics education, has to be done for sustainable development. Sustainable development requires innovation in all fields so in physics and its teaching methods. The aim of this paper is the study of various applications of differential calculus in physics (the gradient)

1. INTRODUCTION

Pedagogy of sustainable development is a challenge for schools, it faces the essential aspects of preparing children to get involved in sustainable development through participation, self efficiency, knowledge about equality, social justice. Although the teaching of sustainable development tends to constitute an agent of short term change for a more sustainable life, we propose that through this pedagogy, the problem to become innovation in the purpose of achieving new ways of realising the common future by the common experience of belonging to the planet, by participation in problem solving on social issues. Schools should improve their capacity to provide necessary training for students to meet future challenges of a rapidly changing world. Students, as future adults, should be aware of issues relating to the existence and use of conventional energy, renewable, pollution reduction issues, global warming, etc. As future specialists they need to find and implement new and innovative technologies, to use unconventional energy, in order to minimize the negative effects exerted by humans on the environment and in the purpose of raising the quality of life on the planet. Sustainable development requires active participation in schools and might become the field in which students and teachers may use their knowledge and skills in implementing sustainable development in society. This should not be seen as a predetermined direction, but it must be understood the fact that there is the possibility of various options in the decisions, alternative solutions and development pathways.

2. THE GRADIENT

Spatial characteristics and can be described using vectors resulting from the application of differential operators on scalar data functions. From historically point of view, scientists have created these operators to develop laws of Newtonian mechanics and to bring them to a form as simple. Thus, physicists have had an important role in the development of this branch of vector calculus.

The operator „∇” and the gradient

In the general case of a scalar function of class c_1, $f: \boldsymbol{R}^3 \to \boldsymbol{R}$, $(x, y, z) \to f(x, y, z)$, we have variations on all 3 directions of Cartesian coordinate system. Thus, we have to consider all 3 components (x, y, z) we create a vector that takes into account variations of the scaling function on this components. This vector is the gradient of the function and is defined as:

$$grad f = \nabla f = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}\right)$$

Each component of the gradient vector takes into account the variation of the function on a particular coordinate axis. In the general case of an n dimensional function, $f: \boldsymbol{R}^n \to \boldsymbol{R}$, the gradient of the function will be a vector of n components and is defined as:

$$\nabla f = \left(\frac{\partial f}{\partial x_1}, \frac{\partial f}{\partial x_2}, \frac{\partial f}{\partial x_3}, \dots, \frac{\partial f}{\partial x_n}\right)$$

Thus, as above, we conclude that ∇ is equal to:

$$\nabla = \left(\frac{\partial}{\partial x_1}, \frac{\partial}{\partial x_2}, \frac{\partial}{\partial x_3}, \dots, \frac{\partial}{\partial x_n}\right)$$

or, three-dimensional:

$$\nabla = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}\right)$$

Two important properties of the gradient are related to operations with functions. Thus, if f and g are two scalar functions of n variables we have the following relationships:

$$\begin{cases} \nabla(\mathrm{f} + \mathrm{g}) = \nabla \mathrm{f} + \nabla \mathrm{g} \\ \nabla(\mathrm{f} \cdot \mathrm{g}) = \mathrm{g} \cdot \nabla \mathrm{f} + \mathrm{f} \cdot \nabla \mathrm{g} \end{cases}$$

3. APPLICATIONS OF THE GRADIENT IN PHYSICS

Application 1.

We can distinguish four types of gradients that give rise to four types of transport phenomena:

a) Diffusion - the migration of a substance along a concentration gradient (chemical potential).

$M_S = -D_S \cdot dc_S/dx$ - The relationship expresses the first law of Fick

Building on this relationship, Fick was able to express the variation in time of concentration of a substance S under the action of a linear concentration gradient of dc_S/dx. (MS is the mass of substance, the DS is the coefficient of diffusion).

Concentration gradient establishes an electrochemical potential through the cell membrane that directs ionic motion under the laws of diffusion and electrical drift. This may explain the assimilation by the human body of the Ca+, Na+, K+, Cl- ions, etc.

b) Heat conduction - transfer of heat along a temperature gradient.

Because of the temperature gradient is produced the atmospheric refraction too.

Space heating system with static components: radiator under the window and radiators on the inner wall provides the temperature gradient vertical-horizontal in the imposed limits in the case of good sealing windows.

Floor heating system is advantageous because of the small temperature gradient and does not form drafts.

Air purifiers (designed discharge gas and odors in the room and introduce fresh air) - because of the temperature gradient occur condensation and by default damp phenomenon and its specific odors.

c) Electrical conduction - electrical charge migration along a gradient of electric potential (will be addressed in greater detail in the application 4).

d) Viscosity - mechanical momentum transfer along a gradient of velocity.

Application 2. We took the example with a gas temperature which varies in function of the position and said that we want to introduce a vector to show us the direction of heat transfer and the speed with which it is transferred. We define vector $\vec{h} = \frac{\Delta Q}{\Delta A \cdot \Delta t} \cdot \overrightarrow{e_h}$ a vector that plays the amount of heat ΔQ which runs through an area ΔA during Δt. From the heat transfer law we know:

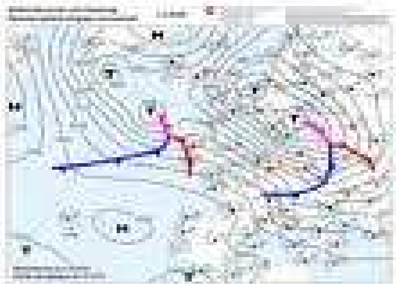
$$\frac{\Delta Q}{\Delta t} = \chi \cdot \Delta A \cdot \frac{\Delta T}{\Delta S}$$

In infinitesimal case, the ratio $\frac{\Delta T}{\Delta S}$ is the derivation of the temperature by the direction of propagation of heat (s) and we can write it in Cartesian coordinates as ∇T. So, passing ΔA to the left and taking into account that the heat transfer takes place from the higher temperature to the below temperature, we obtain the relationship:

$$\vec{h} = -\chi \cdot \nabla T$$

Application 3.

A similar analysis can be made on the drafts movement according to the pressure values at different points in space. Pressure gradient is the vector that will indicate current direction and intensity of airflow that tends to establish equilibrium. Analyzing a synoptic map of the ground is easily found that between two different points on Earth exists surface pressure differences which are called Baric gradient or gradient of pressure (calculated in millimeters of mercury or millibar). Baric gradient is always perpendicular to the isobaric and is directed from high pressure to low pressure. So, the isobars are more frequent, Baric gradient is higher and the winds will have a higher intensity



Application 4.

The operator „∇” is very much used in physics, especially in field theory. Thus, this operator is found very often in electromagnetism and with its help are written the 4 equations of Maxwell which underly the theory of electromagnetism. For now, we will summarize other equation also very important: the equation which connects the electric potential and the electric field intensity.

Electric potential at a point is defined as mechanical work done by electric field forces to move the unit load from that point to infinity in some way. Thus, we have:

$$\varphi(P) = \int_P^\infty \vec{E} \cdot \overrightarrow{ds} = \int_\infty^P \vec{E} \cdot \overrightarrow{ds}$$

The definition considers that the electric potential at infinity is 0 and is considered as a potential reference. If we want to find the potential difference between two points then we have the relationship:

$$\varphi(A) - \varphi(B) = \int_A^B \vec{E} \cdot \overrightarrow{ds} = \int_B^A \vec{E} \cdot \overrightarrow{ds}$$

At limit, when $A \to B$ we have $d\varphi = -\vec{E} \cdot \overrightarrow{ds}$. Thus, $E = -\frac{d\varphi}{ds}$ and is the derivative of electric potential in the direction s. Because we want a form of vectorial expression we use the gradient in Cartesian coordinates and we obtain:

$$\vec{E} = -\nabla\varphi$$

This is the relationship between electric field and electric potential and is one of the fundamental equations of electrostatic.

Earth is an electrified sphere, whose voltage varies with altitude in huge proportions, going as for 1m bump up to 100 V and even more! In some cases the potential gradient for 1 m level difference reach even several thousand volts! As a human being has a height of about 1.5 to 2 m his head may be subjected to a voltage significantly higher than the lower regions of his body, which should not be neglected.

Lightning starts with an invisible download, of low intensity, formed by free electrons, coming from ionization by collision at the bottom of the cloud, moving under the action of the electric field present, forming an ionised channel. This phenomenon, called ”pilot strimer” is a common form of flame propagation of a long electron avalanche, accompanied by the propagation of a ”positive strimer” through the avalanche channel. The pilot strimer forwards relatively slowly through the air still insufficient ionised. If the potential gradient is just the amount necessary for ionization to occur, the minimum speed of the pilot strimer is of 105 m/s and it increases for higher values of potential gradient.

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