A Cycle-Ergonometer

Costa MFM

Introduction

The ability to integrate, to reason and to operate in situations involving diverse and varied types of knowledge from typically "not related" fields – physics, biology, maths, chemistry, ergonomics…- in our education system it might surely be of utmost importance in a sound effective science education [1].

The hands-on activity herein proposed intends to tackle this need of interdisciplinary through activities directly related and significant to our everyday life [2, 3]. We propose the study setting up and use of a digital cycle-ergometer.

A cycle-ergonometer can be defined as bicycle that, in general, is kept stationary and to which are adapted instruments that allow measuring the physical effort developed during the pedalling process [4].

Physics, ergonomics and life…

The measurement of the physical effort developed by an individual in the course of a certain physical activity, may give relevant information allowing doctors and health technicians (mainly of sports and rehabilitation medicine) and also ergonomists to assess the patient or athlete condition or physical state. Overall physical condition can be characterized but also different medical situations can be detected even in early stages of evolution, i.e. hearth diseases [5, 6].

Ergonomics can be succinctly defined as the scientific discipline concerned with the study of the interaction between man and the physical or technical environment where he lives in, studying different human activities - at work, in sports, leisure, etc. - and the influence of certain environmental conditions on individuals [6,7].

There are various ways to accomplish this measurement. One of them is the employment of the ergonometric bicycle or ergonomic cycle frequently used for instance in sports to assess the athletes' physical conditions [5-8].

A homemade cycle-ergonometer

In the cycle-ergonometer we assembled (Figure 1.) the energy spent by the user while cycling is registered through electromechanical energy conversion using an alternator or a dynamo.

ISBN 978-989-95336-2-2

Figure 1. The homemade cycle-ergonometer

Figure 2. Details of the coupling of the electromagnetic energy conversion units to the *stand-still* bicycle

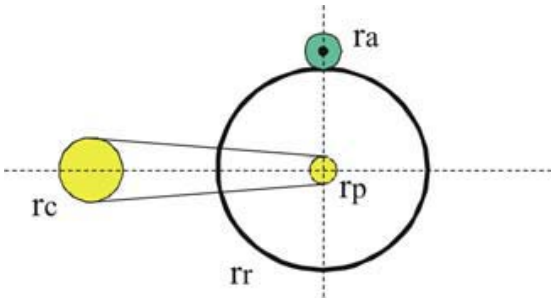

Figure 3. Simple mathematical relations of elementary mechanics should be sorted out

The DC generator shaft will be connected to the back wheel of a fixed bicycle in such a way that when the user pedals the generator' rotor rotation (in the case of the alternator an excitation current allow us to control the amount of mechanical resistance to cycling) will generate an induced electrical current (Figure 2.). The output electrical signal, proportional to the pedalling rotation speed (Figure 3.), is digitalized processed registered and presented in real time to the user himself at the monitor of a microcomputer attached to the bicycle' wheel [9,10].

The energy spent by the user while pedalling can be calculated from the dissipated electric power in a load resistor at the DC generator. However, it has been verified that only about 25% of the user's spent energy (the acquired energy from the "transformation" of ingested foods) is effectively used to make the bicycle pedals movement (from the remain most will be freed as heat - the average body temperature during intense sport activities can surpass the 39/40 ºC). As well a certain amount of energy is lost in the mechanical parts and in the direct-current generating machine [11, 12].

ISBN 978-989-95336-2-2

Study and using the cycle-ergonometer

Cycling can be a rather demanding activity in physical terms [12]. Before using the cycle-ergonometer it is very important to guarantee that the users do not suffer from significant health problems. Besides being necessary to verify if the users know of any health problems they might have - cardiac diseases, respiratory problems, renal or hepatic insufficiency, hypertension, ... - it will be necessary to carry out a short test. The user should pedal at moderate speed and mechanical resistance during a couple minutes. The cardiac rhythm should be read (during 30s) before the exercise and 30 seconds, 1min30s and 2min30s after its conclusion. Users can be considered "apt" if they present a deceleration rate of the cardiac rhythm higher than 10 pulsations per minute.

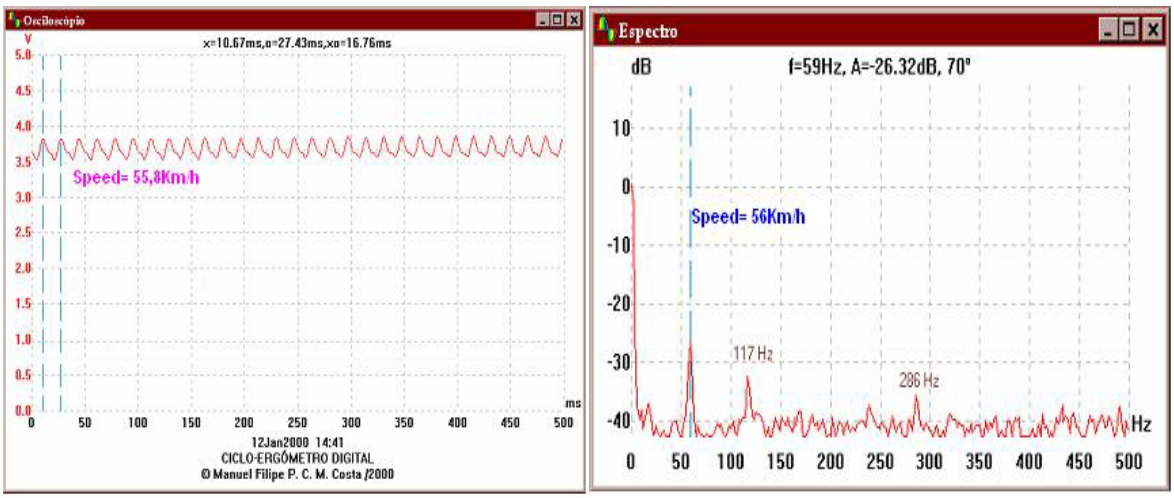

Figure 4. The voltage generated with an alternator at a certain excitation current during a pedalling process

Several questions may be raised along the study and use of this cycle-ergonometer. Let us just draw your attention on the way the paddling process unrolls. A careful observation of the registered graphs, like the one presented in Figure 4, may indicate that the cycling effort is developed alternately through the two legs, on the two pedals, and that when, for example, the right pedal goes down "pushed" by the respective leg, the left one goes up "dragging" the left leg. When the right pedal reaches the lower level, the left pedal will start "to be pushed" by the left leg (entering the right leg in "rest"), but not in a homogeneous way: until the horizontal position (roughly) the force developed by the leg will be higher and from this point on it will probably be more difficult to push the pedal down to the lower level (when the left leg almost does not have to make effort), "recommencing" then the action of the muscles of the other leg. On Figure 5 we intend to illustrate this process.

ISBN 978-989-95336-2-2

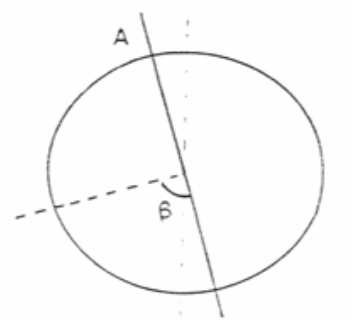

Figure 5. The pedalling process presents a particular sequence that is rendered evident on the graphs representing the evolution of the *effort* spent during the process (Figure 4)

References

[1] Costa MFM, Learning by research, Proc. Soc. Photo-Opt. Instrum. Eng., 3527: 173-181, 1998.
[2] Swany PN, Put the real world in the physics curriculum, Physics Today, 48: 15, 1995.
[3] Meiners H, Physics demonstration experiments, Ronald Press Company, 1970.
[4] Ghista D, Perspectives in biomechanics, Harwood Publishers, 1978.
[5] Edholm OG, A biologia do trabalho, Bibiloteca Universitária Inova, 1968.
[6] Konz S, Work Design, Grid Publishing, 1979.
[7] Grandjean E, Fitting the task to the man, Taylor & Francis, 1979.
[8] McCormick E, Human Factors in Engineering and Design, McGraw Hill, 1976.
[9] Fitzgerald R, Grabel H and Higginbothan S, Engenharia eléctrica, McGraw Hill, 1981.
[10] DeFrance J, Electrical Fundamental, Prentice Hall Publishing, 1969.
[11] Brouha L, Psychologie et industrie, Gauthier-Villars Editeurs, 1963.
[12] Durnim J and Passmore R, Energy, work and leisure, Heinneman Books, 1994.

Paper presented at the 3rd International Conference on
"Hands-on Science. Science Education and Sustainable Development",
Braga, Portugal, September 4 to 9, 2006.

ISBN 978-989-95336-2-2