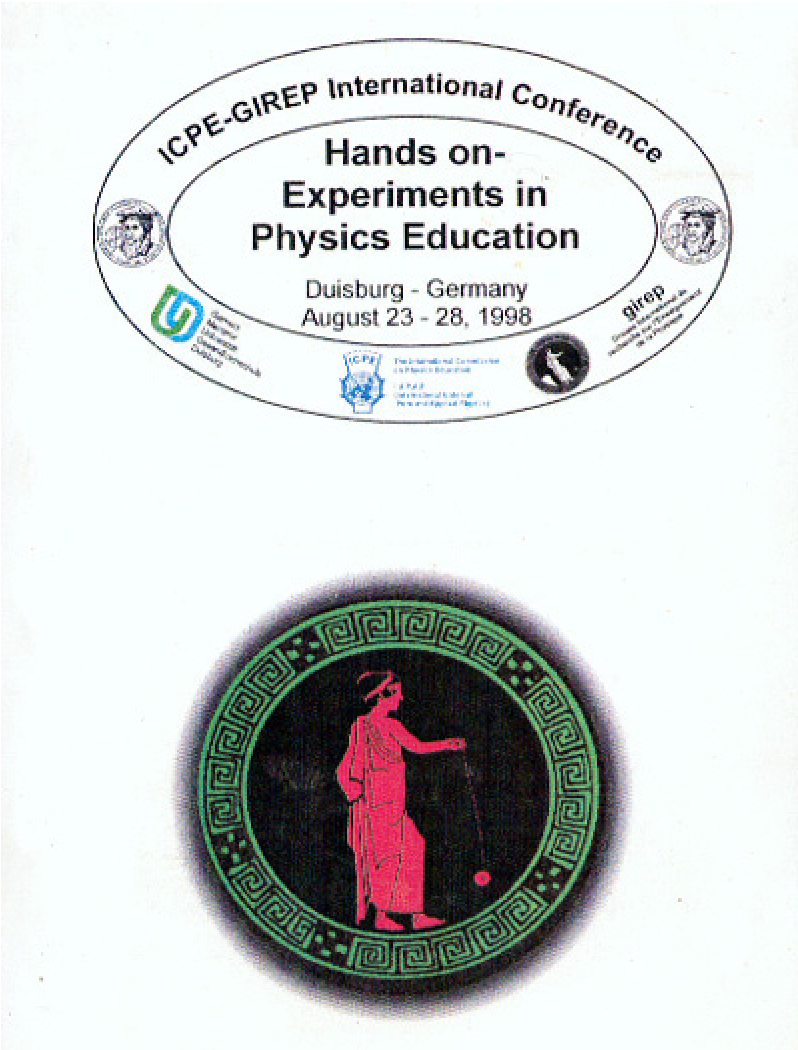

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THE KYNDALON OR XILIKI IN GREEK TRADITION AS A TOY AND AN EXPERIMENT - ITS CONSTRUCTION, MODE OF OPERATION, SIMULATION, PHYSICS AND OUR TEACHING METHODOLOGY

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ABSTRACT

The physics of the rigid body along with all the associated physical quantities, i.e. force, acceleration, moment of inertia, rotation, angular momentum etc., is presented through a very popular Greek traditional game, played even nowadays. The traditional Greek game named kyndalon (version), xiliki or tsiliki is used as a means of developing a relevant teaching methodology of this subject. This outdoors game is quite simple to construct (it takes only two pieces of wood), but requires a well established knowledge of physical phenomena, or the intuition of the experienced player which may readily be transformed into physical study through proper motivation.

Specifically the materials used to construct the pieces of the toy, as well as the way they are put together, are described (and shown...). Then a reference (and practice...) is made to the way this game was / is played (number of players, aim of the game etc.), giving emphasis on a number of variations under which lie several specific physical principles.

A computer-based simulation / visualization program is also presented which enables the user to study the process of the game, to vary initial conditions, to measure physical quantities, to graph results etc. The user may also interactively play the game from the computer.

1. INTRODUCTION

The ancient Greek game named Kyndalon (or Xiliki or Tsiliki - Kyndala, Xilikia or Tsilikia in plural) is / was played not only in Greece but in a number of countries such as Albania, Poland, India etc.

2. CONSTRUCTING / PLAYING THE GAME

The first step to construct the game is to choose a piece of wood of cylindrical shape (a branch from a tree should do), the sides of which are then sharpened in order to create a cone-like surface. These surfaces, when properly carved and successfully hit upon, will enable the xiliki to lift high in the air while rotating. The player manages to lift the xiliki by striking either one of its sides using a second piece of wood. While xiliki is rotating, the player tries to strike a second blow, in order to send it as far as possible.

In a variation of the game, the aim is to have xiliki rotating with great frequency, so as to make it difficult for other players to catch it on the air. In this case the second strike must be applied in such a way as to increase the angular velocity caused by the first blow. This means that the force must be applied away from the middle of xiliki, so that its torque will give the desired angular acceleration.

In another variation, the idea is to hit xiliki in such a way as to send it as far as possible. In this case of course proper care must be taken in order that the second strike aims somewhere in the middle of xiliki's length, so that most of the energy transformed to it will become kinetic energy, thus resulting in the covering of the longest possible distance.

In a third variation, the player tries to make the xiliki land as near as possible to a formerly designated point which can either be a stone, a piece of wood which has been firmly fixed on the ground, or the landing point of other players' xilikia. From the second case stems the ancient Greek phrase "Passalos Passalo ekroyeto", which refers to a piece of wood knocking on another piece of wood, and it has, through the ages, become a Greek saying.

In most cases players calculate the distance covered by xiliki using the second piece of wood (the one they used for hitting xiliki) as a measuring instrument / unit.

A reconstruction of the game was made by a group of children working in collaboration with researchers from the Physics, Technology & Environment Laboratory of the Pedagogical Department P. E. of the Athens University. During this reconstruction, a number of xilikia were constructed in the traditional way, and several variations of the game were tried out. The whole process was filmed, and a short clip from this film was incorporated in the software developed for the simulation of the game.

3. SIMULATING THE GAME

A computer-based simulation / visualization program was prepared, in order to facilitate the understanding of the physical laws governing the game.

A number of parameters, such as the sharpness of xiliki's edges, xiliki's weight, length etc., may be defined by the user through specific controls placed inside the window of the program. The user may also interactively lift the xiliki (using the mouse) and place it - or let it drop - wherever desirable.

Once the initial conditions of the game have been determined, the user may apply a force on xiliki. The program designs a vertical force vector inside the playground, the magnitude of which varies as the user clicks on the appropriate scroll bar. As in the case of xiliki itself, the user may use the mouse to move the force around the screen. Special care has been taken in order not to allow the force to be moved inside xiliki's volume, or inside the ground.

As an additional visual aid, the user may choose to have the program draw a grid on the screen, in order to facilitate the process of measuring distances.

Next, the user may initiate the simulation process, by clicking on the appropriate button. The program responds, by gradually moving the xiliki in the way determined by the two forces (i.e. its weight and the externally applied force). The simulation proceeds at a slow pace, but it may readily be accelerated by the appropriate controls included in the user interface. Along the simulation process, the program presents a qualitative / semi-quantitative visual update of the magnitude of torques in the form of horizontally oriented color bars, the length of which is determined by the torques' magnitudes. Specifically, the torque of the xiliki's weight (red bar), the torque of the externally applied force (blue bar) and the total torque (yellow bar) are presented. Along with these, the same technique is employed in order to visually represent the magnitudes of xiliki's linear velocities in the x- and y-axes.

In the beginning, and assuming that the point of application of the external force lies somewhere along one of xiliki's sharp edges (for example the left one), xiliki rotates about the left base point of its edge (Point A in fig. 1). As soon as the outermost point of xiliki (Point B in fig. 1) reaches the ground, then the center of rotation shifts. As a result the magnitudes of the torques of the forces, undergo a - most of the times -

substantial change.
From that point on, xiliki's behaviour / movement depends on its angular speed, acquired during the first phase of the rotation process.
If this angular velocity results in a vertical component of linear velocity with large enough magnitude to lift xiliki from the ground, then the simulation continues with xiliki's elevation / flight in the air. The game ends as soon as xiliki lands on the ground. At that moment a message appears notifying the user that the game has ended.
If, on the other hand, initial values / conditions lead to an unsuccessful result (for example, xiliki does not lift, or it does not have enough speed in order to travel far), then a message appears informing the user of the problem, while suggesting a number of solutions (i.e. change the point of application of the external force, decrease xiliki's weight, decrease xiliki's length, increase sharp edge's length etc.).

In either case the user may repeat the game, following the directions presented on the screen. Of course, variations concerning initial values are allowed, in order to make comparisons and determine the effect that such values have on the final outcome of the game.

4. CONCLUDING REMARKS

A great number of physical principles must be obeyed during the playing of xiliki in order that the game have a successful result. One may safely assume that these principles are/were - at least empirically - known to the players. During playtime this set of rules was communicated to next generations of players, while undergoing several improvements, proven beneficial by the game results. This process in nothing more than actual scientific experimentation (even is a mostly simplistic and elementary form) and, when stressed upon, may be utilized as a starting point in order to develop proper experimental behavior and convert as team of players into a group of Physics students and experimentalists, occupied in procedures taking place outdoors and, what is more important, performing experiments by themselves and studying the results. Thus, the pedagogical dimension and educational value of games in the study of Physics are self-evident.