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Physical Education and Games, and Concepts of Physics: An Interdisciplinary Approach

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Introduction

Systematic international surveys since the mid-eighties have shown that students' attitude towards Physics is rather negative and that the students' indifference is developing progressively, starting at their early school years and increasing as they get older. The students' indifference varies according to the interest of the thematic unit and mainly according to the possibility for active involvement they are offered during the lesson. In an effort to stimulate our students, we should gain advantage from these findings and develop their applicability. We should therefore plan activities that arouse our students' interest by requiring and encouraging their active participation in the learning process. The interdisciplinary approach is expected to offer a solution as it provides ways to enrich our lesson plans with new "ideas", knowledge and information that will motivate our students' involvement.

Sports and, much more, games are amongst the interests of every child. The endeavor to connect "Physics lessons" with games and physical education increases the pupils' participation, and they join the activities with pleasure. Another important point is that presenting physics concepts through games helps pupils to realize that Physics is not only a theoretical science that is only applied in well-equipped laboratories. It is not unrelated to everyday events but, on the contrary, it dominates them.

There have been many publications concerning of Physics through Sports since the end of the eighties. Some of them are based on the analysis of pictures, some others on the use of computers simulation, or on human body modeling. Most of these publications are focusing on calculation of the best attempt by changing parameters, or predicting the results in athletic activities (Borghi, Ambrossis, & Massara, 1993; Witters, Bohets, & Coppenolle, 1992; McMachon & Green, 1979; Arampatzis, 2002).

The present paper is based on an experience-centered approach to concepts of Physics. Measurements and quantitative confirmation of the Laws of Physics have not been included in the aims. This point of view is dictated by the fact that pupils, aged 10–15, are just beginning to come in contact with taking measurements in the laboratory. As a result, if they are asked to make measurements in vivo, without the special equipment required for measurements of human body movements, these activities might just be another overwhelming task.

Presentation of lesson plans

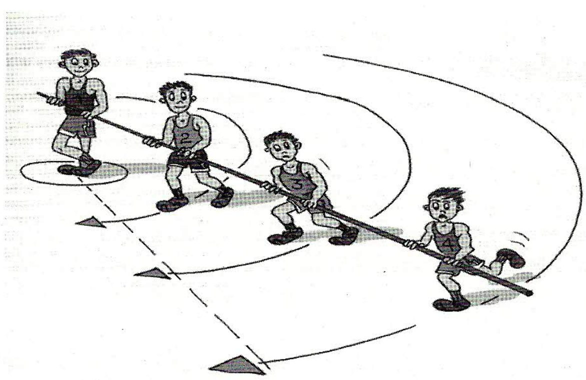
The activities presented below are planned for pupils aged 10-15. The activities are short enough to be demonstrated and completed during a school session. The whole presentation of a topic should be completed with a discussion about similar phenomena that are probably noticed by the children during their playtime or sport activities.

In fact, in every activity we find several phenomena and concepts. However for pure methodology reasons, the teacher must aim at focusing the pupils' attention on one topic at a time.

Activity: "I have to run faster to move side by side with you"

Aim: To show that the linear speed depends on the distance of the center of the circle.

In a small group of pupils we give a light pole[1] (two meters long at least) and ask them to hold it in a line side by side. Their starting position needs to be with the line-up and pole vertical to a wall. Pupils are asked to move all together in such a way that the pole remains always vertical against the wall. To achieve this pupils realize that they all need to move the same distance in the same time period. That means to have the same velocity (direction and speed). In the next activity, pupils are asked to move again side by side, holding the pole, while the first one just turns around. Now pupils have to move in a circular way around the first one as it is shown in Picture1.



Picture 1

It will be easy to realize that the farther they are from the "central pupil," the more distance they have to run to stay in the same line with the pole. That means that to keep constant angular velocity (the pole and the pupils are covering the same arc in the same time), some pupils have to run faster than the others. At the conclusion of the activity, pupils are expected to realize that constant angular

1 Alternative is to use a string, but the string should be kept straight!

velocity does not mean constant linear speed. On the contrary, the farther from the center of the circle you are, the greater linear speed you have to develop. In short: "Linear speed depends on the distance from the center of the circle".

Finally pupils are asked to summarize the activity and answer questions such as: "Could you explain why the pupil who moves at the outer point of the pole needs to get bigger linear speed than the inner pupils? Please explain in your own words." It is noticeable that runners in 800 m, or 1500 m races, try to keep the inner couloirs (line). Why does this happen? Wouldn't it be easier for the runners to avoid the crowd and run in the middle couloirs? What is your explanation?

Two friends are running a race of 400m (one round in a stadium). The first one is following the inner couloirs and the second the outer one. Both runners reach the finish line at the same moment. Who had the higher average speed?

Activity: "Swinging my arm"

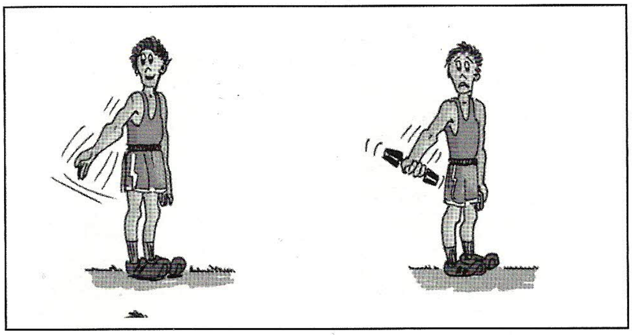
Aim: To show that the pendulum's period depends on its length.

(The distance between the center of mass and the hanging point is the length of the pendulum.)

A pupil is asked to stay in the attention position and move one of his arms forward and backward as in a walking motion. He also is asked to move his arm as fast as possible. Further we ask the pupil to hold a lightweight and repeat the movement of his arm again (Picture 2). He would realize that the movement of his arm that he can achieve is much slower than he first time.

Finally the pupil is asked to fold his arm as in running motion and repeat the attempt.

With his arm folded he achieves a "faster" motion in comparison with the previous attempts.



Picture 2

The teacher may present the motion of the arm as a driven oscillation, and mention that the center of mass of the stretched arm is about the elbow and the hanging point is the shoulder. Pupils are asked to recognize the change of the center of mass when they hold the lightweight or they fold their arm.

During the fold-arm-attempt, the "pendulum-arm's" length was reduced (because the center of mass was moved in a higher position) and the oscillation period was also reduced (that is to mean a faster arm motion).

During the holding of the lightweight, the "pendulum-arm's" length was increased (the center of mass is lower), and the oscillation period was also increased (slower arm motion).

Finally pupils are asked to summarize the activity and answer questions such as:

"Supposing that you watch a clock-maker trying to fix a wall pendulum-clock with an accuracy problem. You would see that he moves the sliding weight very carefully up and down. What is the clock-maker trying to do by that movement?"

"Have you ever paid attention how fast the legs of a small dog move? Could a big dog move his legs so fast?" (Hewitt1992).

"Supposing that you compete with the walking Champion, but you have the right to run, while he walks as the athletes of walking walk. It is obvious, that you will win, because ...... physics is on your side. Could you explain why?"

A number of concepts in physics, apart from the ones already presented, can be approached in a similar way. For example, torque, average speed, power, friction, inertia, Newton's Laws (force, impulse, action-reaction), centripetal force.

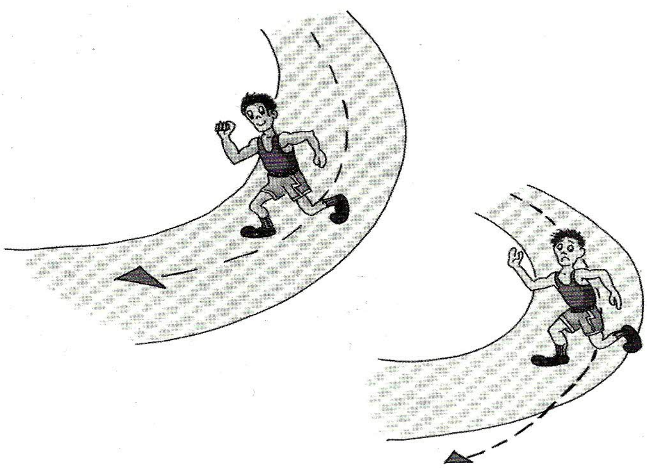
A few activities related to the centripetal force will be presented briefly.

Activity – "I create circular motion"

Aim: To show that a force is needed to change the linear motion into circular motion and "centripetal force" does not denote a new and separate force, but any force, or the vector sum of forces, can operate as "centripetal force".

A pupil is asked to run towards us. At the moment he overtakes us we grab his hand.

Immediately, he starts moving in a circular path. His linear motion has been transformed into circular.



Picture 3

Activity – "keep moving in the corridor"

Aim: In the following activities we try to help pupils derive the relation between the centripetal force and the radius of the circle, while the speed is constant, or the relation between the centripetal force and the speed, while the radius is constant.

The teacher draws two semicircles of a radius about 3.0 m and 2.7m on the concrete floor of the schoolyard, so that a corridor about 30cm wide is formed. Then the teacher creates a similar corridor between 1.0 and 1.3 meter radius.

Pupils are asked to run as fast as they can on the larger semicircle trying to keep themselves inside the corridor. They can easily perform the activity.

Then pupils are asked to repeat the activity in the smaller semicircle. They do not succeed and get out of the corridor (Picture 3).

The teacher guides pupils to identify the static frictional force as the centripetal force in this motion and it remains constant in both cases.

During this activity pupils have a sensation that there are limits on the length of the radius of the circle when the speed and the centripetal force are constant.

Finally they are asked to keep running in the corridors increasing or decreasing their speed. To do that, they all slowdown as they reach the small semicircle.

Summarizing the activities pupils are asked to comment on the speed limits on curved and wet roads. Or to answer questions such as: "Have you ever noticed that in the 200m races the athlete who runs in the inner couloirs ...never (or rarely) wins.

Does centripetal force cause that failure?

Activity – "Increasing the centripetal force"

A pole is fixed vertically to the ground near the center of the small radius semicircle. A pupil is asked to run fast and keep himself inside the corridor. The pupil grabs the pole instinctively and manages to keep himself inside the corridor. He is asked to explain how the pole helped him. We guide the pupils to think about the need for a greater centripetal force to keep themselves on track. The force that was added to the static frictional force was the reaction force from the pole.

Conclusions

Teaching experience for many years shows that the use of the schoolyard as a "physics laboratory" causes a delightful jolt among the pupils and motivates them to participate and their remarks and questions lead to a better understanding of physics.

The presented activities and other similar activities as well, cannot achieve the desired comprehension level of the corresponding concepts by the pupils just by themselves. These activities should be considered as a "complement", as a different approach to the topics of physics classes, which can give a new inspiration to an oft-monotonous process by their originality. These activities add an important visualization and experience component in the form of "muscle memory" (Berg, 2004).

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