Teaching basic physics through excel spread sheets

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Abstract

There is a strong dependence of mathematics in understanding the basic laws of physics. Many physics problems demand a sound mathematical knowledge and can be solved or interpreted in a quick or better way with the basic mathematics. Some of the physics concepts which have a mathematical relationship are the motion of bodies in one and two dimensions, charging and discharging of a capacitor, nuclear radioactivity, simple harmonic motion. The above concepts demand the understanding of the algebraic, trigonometric exponential and probability functions. The dynamic mathematics can also lead to a study of physical phenomena, if coupled at the right point of delivery by the instructor. Thus, the maths tutors that have already being designed can also serve the additional purpose of learning physics. This work highlights the physics concepts that can be dealt with existing dynamic and interactive mathematic learning environment.

Keywords: Physics problems, mathematical functions, interactive mathematics**.**

Resumen

Hay una fuerte dependencia de las matemáticas en la comprensión de las leyes básicas de la física. Muchos problemas de la física exigen un conocimiento matemático sólido y pueden ser resueltos o interpretarse de manera rápida o mejor, con las matemáticas básicas. Algunos de los conceptos físicos que tienen una relación matemática son el movimiento de los cuerpos en una y dos dimensiones, la carga y descarga de un condensador, la radioactividad nuclear, el movimiento armónico simple. Los conceptos anteriores exigen la comprensión de las funciones exponenciales, trigonométricas y algebraicas de probabilidad. Las matemáticas dinámicas también pueden dar lugar a un estudio de los fenómenos físicos, si se combina en el punto exacto de la entrega por parte del instructor. Así los profesores de matemáticas que ya se están diseñando también pueden server al propósito adicional de aprendizaje de la física. Este trabajo pone de relieve los conceptos de la física que se pueden tratar con el ambiente de aprendizaje matemático dinámico e interactivo existente.

Palabras clave: Problemas de física, funciones matemáticas, matemática interactiva.

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I. INTRODUCTION

Over the past decade, teaching in high schools and university has shifted from the teacher centric environment to the learner centric environment. The concept is also termed as active learning, where learners are continuously involved in various activities including quiz, role play, demonstrations, model making, group discussions. Active learning has not been precisely defined in education literature but has the general characteristics that students can be engaged in various activities including reading, writing discussing and giving importance to students exploration of their own thinking values [2]. Techniques like the mind mapping and discovery sheet have also been used to achieve the student centered approach [3]. Teaching of difficult concepts is more challenging to the teacher. This is already emphasized by Kholer and Misra on "what makes concepts difficult or easy to learn" [4].

Teaching Physics has also changed over the past decade. The internet has been used as a vital tool in making students actively involved in the classroom environment [5]. Physics teaching has also been made more interesting and active environment can also be maintained by simulations. Kurt Squire has made the attempt of teaching electromagnetism by simulation [6]. Yiming Ding has designed a computer simulation laboratory to simulate the diffraction grating pattern by C++ program [7]. Arotius, Kohler and Misra have analysed the effect of planning a game, physicus and the results are in support for teaching physics through games [8]. Yannis Hadzigeorgiou [9] has highlighted the importance of teaching by a story telling concept especially when the teacher has to teach the laws of physics. William D. Gearce has highlighted the reasons for the failure of physics teaching by traditional methods [10].

There is a demanding situation from teachers to change the mode of teaching to get effective learning in classroom. Over the years teaching has changed from the blackboard, Power point presentations, seminars to group discussions, games, animations, simulations, quiz. Some researchers have also suggested a mixed mode of teaching in the classroom to benefit all type of learners, L. A. Dobrzański, F. Brom, Z. Brytan have demonstrated the importance of teaching materials science by moodle and also the importance of mixed mode of learning [11]. Morten Brekke has reported on using computer technology in physics, mathematics and computer science [12]. Recently Martinova and Zakaria Karadag have presented a new way of learning limits by a dynamic mathematic and interactive learning environment by use of excel and geogebra [1]. The present work deals on extending the same concept to physics teaching. Use of DIMLE can offer the following advantages to physics teaching.

a) Achieving active learning which is most desired.
b) Individual thinking from each learners.
c) Appreciating the mathematics involved in physics.
d) Understanding the behavior of a physical law at the boundary conditions.
e) Analyzing the rate of change of the behavior.
f) help the students think of higher cognitive level in blooms taxonomy(apply, analyse and design).
g) May create research interest for subject beginners.
h) Be highly motivating for the visual learners, innovators and satisfy all type of learners.
i) It may also help the student to remember the concept for a larger time when compared to conventional teaching.
j) Economical way of teaching instead of performing live experiment in special cases (radioactivity, nuclear collision).

II. TEACHING PHYSICS WITH MATHEMATICS ENVIRONMENT

Mathematics Environment can be used to teach all those concepts in physics where mathematical equations or mathematical functions are involved.

Example include: Algebraic function in motion in one dimension, trigonometric functions in simple harmonic function, exponential functions in radioactivity, complex functions for dielectric constant.etc.

The above process can be taught with the excel sheet and parallel analysis in the classroom.

A. Motion in one dimension

Imagine a ball falling from a height of 10 m .The student can be asked to find the velocity at any point acceleration and impulse imparted to the wall, nature of collision etc

The above situation is best understood by allowing the learner to drop the ball from 10 m, measure the time of fall with a stop clock and calculate the velocity by the corresponding formulae.

v= sqare root(2gh).

Then, the mass of the ball can be determined and the change in momentum can be determined by 2mv.

The process of change in velocity can also be understood with a excel spread sheets and it will be more useful when the height is extremely less .Even in the case of dropping the ball from a height of 10 m, it will be very difficult to measure the time accurately. Hence alternative aids of teaching are to be adopted. Animation are handy in the current context but studying through the excel sheet will demand more involvement and active learning from the student.

The teacher can give the following *instructions* to the learners with a specified time line to complete the task.

a) *What are the values of height that can be given to the ball?*
Since the ball is dropped from a height of 10 m from bottom of floor, the height from top is 0, 1, 2, 3, 4, 5……10.
Some students can think of intermediate values 0, 0.5, 1.5…. 6.5, ... 10.
Others may enter values at random 4.9, 6, 9.8, 10.

b) What is the relation between the velocity and displacement(height) for a freely falling ball.
v=sqare root(2gh) where g is the acceleration due to gravity.

c) Enter your choice of displacement as in step a) and the formulae in column B of excel sheet and plot the graph of velocity and displacement.

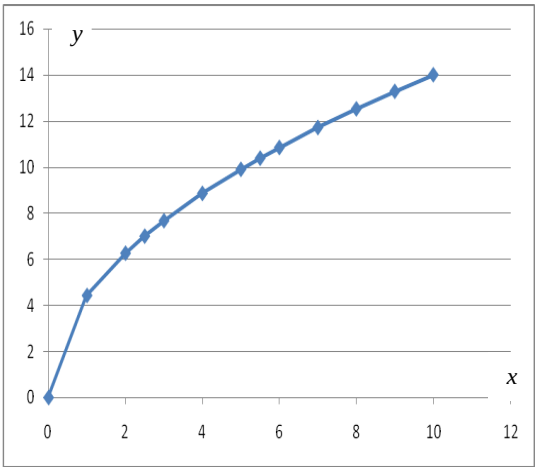

FIGURE 1. Graph with displacement on *x* axis and velocity on *y* axis.

d) What are the formulae for time of fall from the top to the bottom of the floor? Plot the graph of time and height of the ball Sqrt(2g/h).

The above problem can further be made interesting by asking the student to consider the collision between the ball on different surfaces like tennis ball on marble floor and rubber ball on sand or elastic ball on glass. The student can be asked to repeat the questions (*abcd*) given above for elastic and inelastic collisions. Elastic collisions are collisions in which momentum and kinetic energy are conserved. It is an ideal

collision. Inelastic collisions are real collisions as the examples cited above and are collisions where energy is dissipated as heat. The students are expected to interpret the change in velocity for elastic and inelastic collision.

In elastic collision, the ball rebounds with same velocity on reaching the floor and in inelastic collision the velocity of rebound changes according to coefficient of restitution between the body and the surface. The student can best understand this concept by doing the experiment practically but since the ball rebounds fast, the learner may not be able to appreciate the decrease in velocity in an inelastic collision with time. By plotting the same on an excel sheet the student will understand the rate of change and also appreciate the physical phenomena of damping (energy loss in a system).

The student is expected to get the same graph as shown in figure 1. The process repeats indefinitely for elastic collision but for inelastic collision as time passes the maximum height decreases for each collision and the ball finally comes to rest.

The teacher can give the chance for the student to explore various aspects from the graph like finding the slope of the time velocity or velocity –displacement graph and analyze them further. The use of excel as a dynamic mathematics' environment is helpful in achieving the higher end of blooms cognitive domain like apply, analyse and evaluate category [13]. At the same time, the importance of mathematics in understanding physics is much appreciated by the learner. Many physical phenomena can be fun when explored with excel sheets or other suitable environments. Further DIMLE is also a brain based approach on students as elaborated by Erkan Akyureck [14]. The same case of motion of a falling body has been done by an experiment set up in combination with a computer based measurement by Elmar Bergler [15].

III. CONCLUSIONS

The importance of mathematics in understanding physics is highlighted with the help of excel sheet. Thus dynamic mathematics' environment is a vital tool for achieving active learning in the class. The mode of teaching will be individual based learning by the student with a set of instructions from the teacher. The use of the dynamic mathematics' environment can be suitable to all categories of learners from slow to fast. Further, it is a tool in achieving the higher end of blooms taxonomy of cognitive domain.

If a particular session is coupled with laboratory session followed by a dynamic mathematics' approach students can remember and highly appreciate the concept. It can be the best alternative to power point presentations, ppts, quiz. With the obtained input, the teacher can motivate the student to design and evaluate the real time devices and also access quality of existing devices. It can leave the student with a quest for knowledge and to explore all physical phenomena for a better understanding. The use of spread sheets is a method of active learning and active learning has been reported as successful with ISLE (16)The undergraduate student can be highly motivated from a research perspective. Geogebra has also been used for calculating the surface area of water in a rolling cylinder by Muhareen Aktumen [17].

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