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Kinematics of a bicycle with Phyphox

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Abstract. Currently, the use of bicycles within the university campus is very common and it is an opportunity to teach our students the kinematics by studying the movement of the bicycle. For this purpose, we used the 3D point position GPS locator, an application of Phyphox a free software for smartphone. The smartphone with this application was attached to the bike to measure its movement while a person rides it on any road. In this work we discuss the process that its follows to study the concepts of kinematics when they ride a bike with the GPS tracker.

1 Introduction
Classical mechanics is generally taught to university physics students in their first year of university. It begins with kinematics where important concepts that describe the motion of a particle are introduced. Kinematics is often referred to as the geometry of motion [1] and is taken as a branch of mathematics.
This mathematical approach to motion is difficult for students to understand when they experiment with motion phenomena in the laboratory and even more so when these phenomena refer to mobiles of everyday reality that must be described according to the concepts of theoretical kinematics.
To overcome this difficulty in understanding students, we set out to teach kinematics by studying the movement of the bicycle.
2 Motion of a bicycle
In our university, as in many other universities in the world, the free use of bicycles has been promoted among students as a means of internal transport within the university campus and for students to become aware of its environmental impact. We have seen this as an opportunity to teach kinematics outside of the laboratory with the movement of a bicycle.
For this purpose, we used Phyphox[2] smartphone apps of a GPS locator to measure the position of a mobile on any outdoor road. With the smartphone fixed on the bicycle, the GPS sensor measure the movement of the bicycle as a real situation.
The Phyphox-GPS locator, measures the latitude, longitude and height of the position of a mobile every 1 s and saves the data in a spreadsheet that it is used to analyze data.
We collected data with this motion sensor in a closed circuit of the parking lot of our School and we have analyzed the data in a spreadsheet that was imported into Google Earth software for showing of the movement in the same real scene where the movement occurred (Fig. 1).

Fig. 1 A view of the movement of the bicycle in a closed circuit on the parking lot of the Science School.
3 Analysis of the movement.
The data analysis begins with the graph of the motion path and the graphs of the x and y coordinates as a function of time (Fig. 2a and 2b). In this analysis, we make a translation of the geographic coordinates of latitude and longitude to a local XY-system, measured in meters, originating at the beginning of the movement.

Fig. 2 Graphs of the movement of the bicycle. (a) trayectory of the motion, (b) x(t) and y(t) and (c) a straight line motion at constant speed.

Figure 2c shows a part of the motion of the bicycle at constant speed with v = (0.64, 0.50) m/s and 1v1 = 0.81 m/s.
4 Conclusion
The study of the kinematics in an outdoor activity of the movement of a person on a bicycle allows students to establish the relationship between theoretical concepts with reality, because at the same time, they are observers and subjects of experimentation. This dual role establishes a strong mental connection between the experienced and the conceptualized that helps students build better knowledge.

References

[1] Millard F. Beatty Jr., Principles of Engineering Mechanics: Kinematics. The Geometry of Motion. Mathematical Concepts and Methods in Science and Engineering 32. Springer US, 1986.
[2] Phyphox (n.d.). Physical phone experiments. https://phyphox.org/

Primary author: DEL RÍO VALDÉS, José Luis

Presenters: DEL RÍO VALDÉS, José Luis; GONZALES Y HERNANDEZ, Alejandro (Universidad Nacional Autonoma de Mexico)

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