9th INDES 2020

LIMITLESS MIND:

EMPOWERING INNOVATION THROUGH VISUALIZATION

UNIVERSITI TEKNOLOGI MARA

Cawangan Perak

PROGRAM
PROCEEDINGS
ABSTRACTS BOOK

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Copies of this document may be obtained from the Department of Research, Industrial Community, Alumni and Network, Universiti Teknologi MARA, Perak Branch, Bandar Seri Iskandar, 32610, Seri Iskandar, Perak Darul Ridzuan, Malaysia.

ARROVIEWER

Yee Hui Robin Chang[1], Fui Kiew Liew[1], Yit Lian Liew[1], Moi Hua Tuh[2] and Reduan bin Zainuddin[1]

[1]*Faculty of Applied Sciences, Universiti Teknologi MARA, Cawangan Sarawak, 94300 Samarahan, Sarawak*

[2]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Cawangan Sarawak, 94300 Samarahan, Sarawak*

E-mail: robincyh@uitm.edu.my

ABSTRACT

Centripetal acceleration (acen) is an important quantity in the aspect of rotational motion. This value directly influences the centripetal force, which is the parameter determining the success rate of rotation. Object that rotates with low or insufficient centripetal force tends to skew away from its circulating path. However, students who learn the acen concept for the first time often have difficulty understanding its origin, as the production of acen is different from those of linear acceleration, where the latter is produced by the rate of change in linear velocity. In circular motion, the tangential velocity does not vary. Students will therefore become confused as to how acen is formed since velocities at different points on the circumference remain constant. In this work, a handy tool is developed to assist learners to visualize how the change in direction of a constant tangential velocity is responsible for the generation of acen and subsequently the centripetal force.

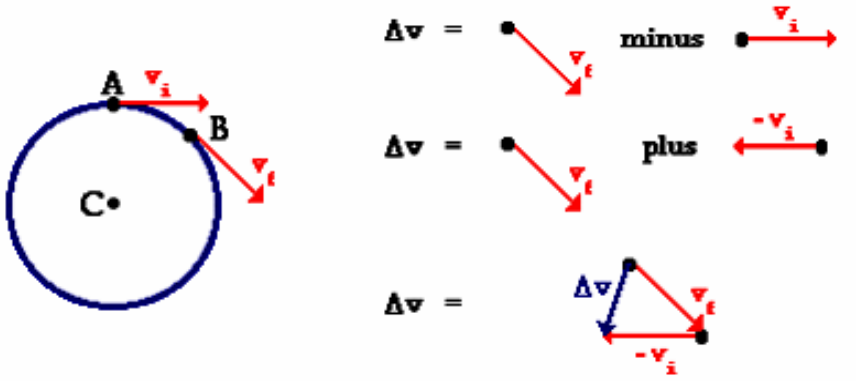
Keywords: centripetal acceleration, rotational motion, tangential velocity, PHY210

1. INTRODUCTION

Object that moves in a circle is always experiencing acceleration, even if it travels around the circumference of the circle with a constant velocity. In rotational motion, the acceleration is produced because of a change in the direction of tangential or linear velocity when arriving at different positions on the circular perimeter. This acceleration is directed towards the center of the circle. As documented by Newton's second law of motion, an accelerating object will naturally experience a net force which acts parallelly with the acceleration. To comprehend the production of centripetal acceleration, apart from possessing a strong understanding of the first law of Newton motion, which states objects in motion tend to stay in motion with the same speed and the same direction unless acted upon by an external force, it is also crucial for students to be able to visualize the change in direction of an unchanged tangential velocity. However, their prior knowledge of linear acceleration is hindering this purpose. Reason being that both centripetal and linear accelerations have different production mechanism, where the latter is produced by the rate of change in linear velocity. The tool developed herein will provide students with a better view of how the change in direction of a constant tangential velocity can lead to the production of centripetal acceleration, which perpetually acts towards the circular path centre.

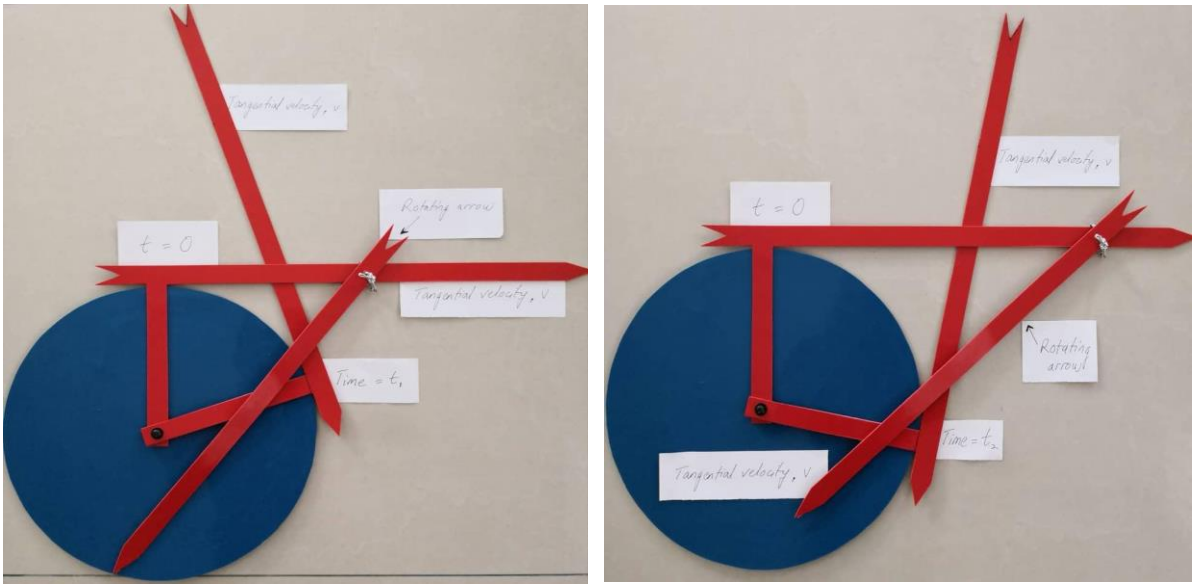
2. APPROACH AND METHOD

In the usual approach, instructors will use the following conventional method to introduce the concept of centripetal force.



In the above diagram, a rotating object initially at A will reach B after a period of time. Note that the tangential velocities at both locations remains unchanged. Students are then asked to extract the tangential velocities at A and B and use these vectors to form an equilibrium isosceles triangular. An equilibrium vector Δv is drawn. The rate of Δv formation denotes the centripetal acceleration. Finally, instructors will request the students to visualize that the direction of Δv is always pointing to the circular path centre, which means centripetal acceleration is also acting in identical direction.

As can be seen, there is no change in the magnitude of tangential velocity and this phenomenon is against the prior knowledge of students, in which they have been repeatedly told that acceleration is the product of variation in velocity over time. Moreover, students will also face difficulty imagining the direction of Δv as constantly pointing to the circular path centre if location of B changes.



(a) First scenario (b) Second scenario

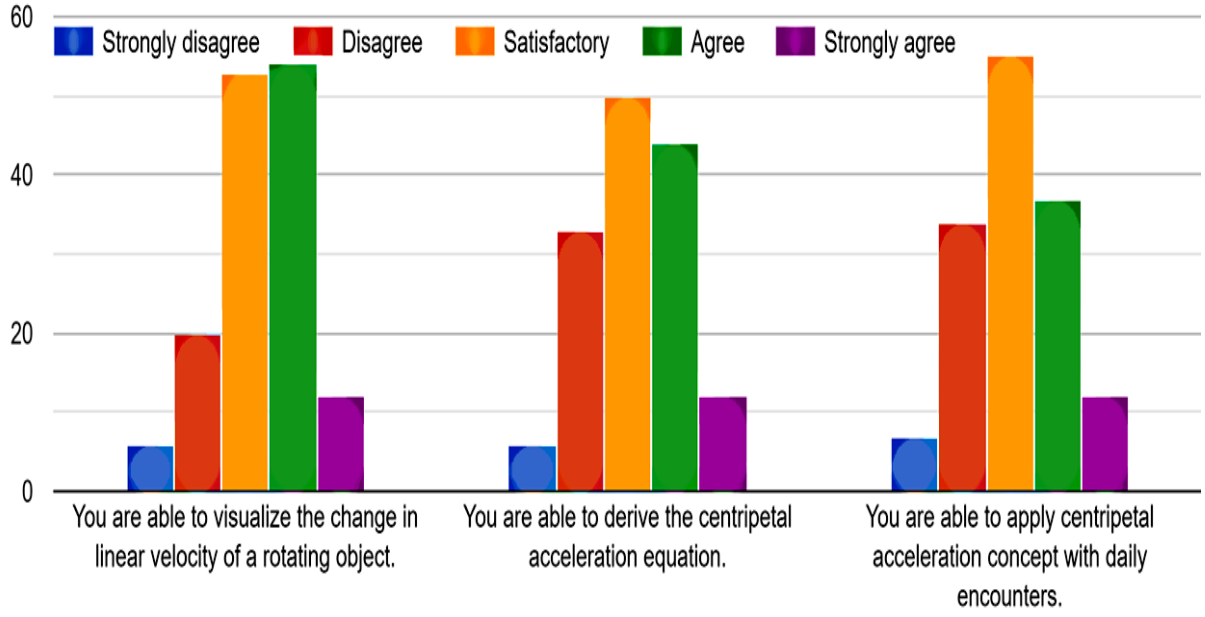
Through the use of Arroviewer, instructors can adjust the position of "rotating arrow" by sliding it along the tangential velocity at A and later rotate it to form an isosceles triangle with tangential velocity at B. At this instance, students can clearly see that the rotating arrow is pointing towards the circular path centre. In the second scenario, with B at a different location, the rotating arrow remains aiming at the circular path centre when an isosceles triangle is formed between itself and the two tangential velocities.

3. FINDINGS

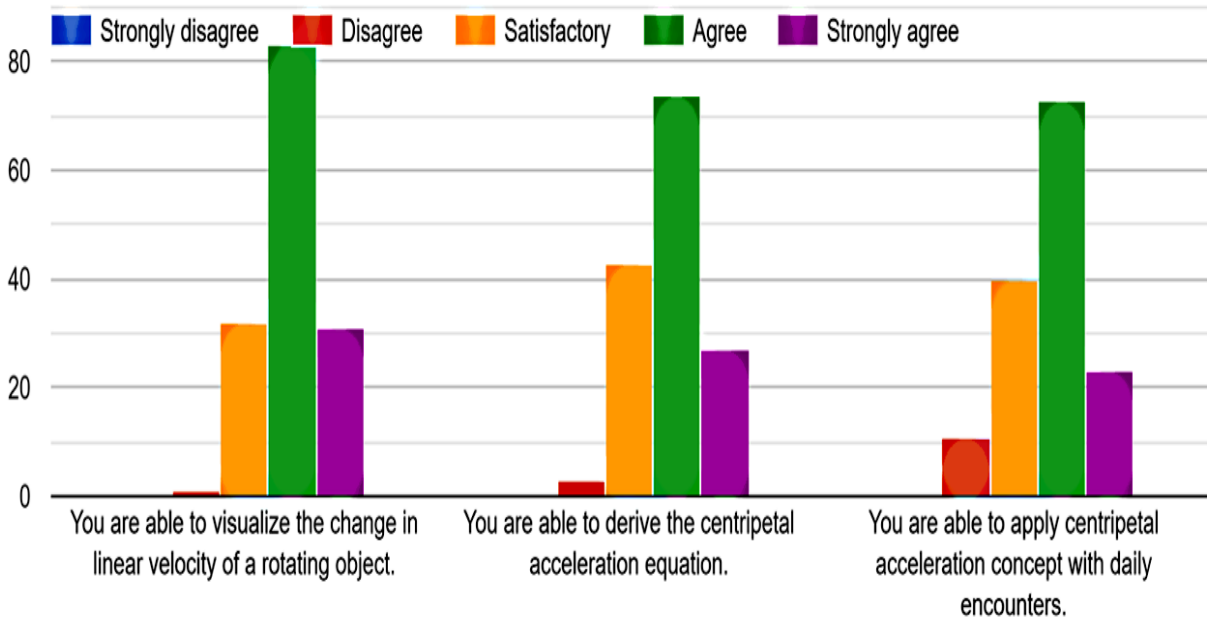
In order to test the effectiveness of the developed tool, a survey was conducted on 145 students taking PHY 210 (Rotational Mechanics and Thermal Physics) course. In the survey, three tasks were posted, namely if the students are able to

- visualize the change in linear / tangential velocity of a rotating object.
- derive the centripetal acceleration equation.
- apply centripetal acceleration concept with daily encounters.

After learning the subject using conventional method, most of the students expressed disagreement and satisfactory agreement when executing the three tasks. Some even chose strong disagreement. Upon switching to Arroviewer, number of students choosing disagreement and satisfactory agreement was drastically reduced. On the contrary, percentage of students who were in agreement and strong agreement when performing the three tasks, increases dramatically. Strong disagreement option was not selected at all. These results imply that the use of Arroviewer significantly enhances the understanding of learners when studying the centripetal acceleration and force concepts.



(a) Students' Perspective (Conventional method)



(b) Students' Perspective (Using Arroviewer)

4. CONCLUSION

In conclusion, Arroviewer was successfully completed and tested. Feedback from students also revealed that they gained better comprehension of centripetal acceleration through Arroviewer as compared to conventional technique. It is suggested that Arroviewer to be used again in the following semesters to assist students to improve their understanding.

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Perak Darul Ridzuan, MALAYSIA
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Kelulusan daripada pihak YBhg. Profesor dalam perkara ini amat dihargai.

Sekian, terima kasih.

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