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Analysis of Physics Concepts in Playgrounds at GoFun Bojonegoro as Learning Materials for Students

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ABSTRACT

Objective: *GoFun Bojonegoro is one of the area edutainments in Bojonegoro which has rides for games and entertainment with an attractive appeal for visitors. This study aims to analyse the physics concepts that exist in several game rides in GoFun Bojonegoro Theme Park. Some of the rides available at the park have interesting physics concepts to learn.* ***Method:*** *This type of research is descriptive qualitative research with observation, documentation, and analysis methods as a form of data collection.* ***Results:*** *There are three vehicles analysed namely, Pirates Ship, Mini Ontang-Anting, and Bom-Bom Car, which works based on the concept of physics. There are various physics concepts in the vehicle, such as the concept of oscillation, centrifugal force, circular motion, Newton's third law, collision, and the law of conservation of momentum and impulse. By integrating physics learning in the vehicle or edutainment make learning more fun.* ***Novelty:*** *This research provides edutainment-based learning that can increase the effectiveness of students in learning physics concepts and make students more active and learning looks fun.*

INTRODUCTION

Everyone knows the 21st century as the information age, the most important foundation for various aspects of life. The learning model in the 21st era emphasises that students have the ability to think critically, connect knowledge with applications in life, master information technology, and communicate and collaborate well (González-Pérez & Ramírez-Montoya, 2022; Wibowo, 2023). One of the steps and strategies needed to adopt an appropriate and enriching learning model is to prepare students to become global citizens. 21st-century knowledge is informal education, and experiential learning is essential in developing learners' skills (Baszuk & Heath, 2020; Morris , 2020). This implies that in developing learning and enriching students' learning experience, various activities outside the classroom must be made to support learning.

Science education, especially physics, has become the main focus in efforts to increase students' understanding of natural phenomena and scientific principles. Physics is one of the subjects where most of the material is abstract (Jatmiko et al., 2021). Studying physics places more emphasis on understanding students' concepts, not on memorising the concepts because by understanding the concepts, the material received by students will be better stored and embedded in the brain's memory (Husnaini & Chen, 2019; Ristanto et al., 2022). Learning physics is not only about explaining the theory but also includes experiments or experiments regarding physical phenomena so that students are better at mastering the material the teacher provides in class. However, to study this phenomenon, it is still mostly done in the room or classroom, it is better if learning it is also done outside the school or through activities in daily life so that students are better at mastering the application of physics concepts directly and their application in life (Astuti et al., 2022; Wati et al., 2021). One thing that can be done is to visit rides or tourist attractions; rides for games are environments rich with opportunities to learn various physics concepts (Suprapto & Mubarok, 2020). This can increase the motivation of students and also make students not bored with learning physics later (Velly, 2021; Löfstrand & Pendrill, 2016).

Edutainment comes from two words: *education* and *entertainment*, so teaching and learning activities become fun (Wanabuliandari & Ardianti, 2023; Salsabila & Kholiq, 2021). Edutainment is also learning that combines education and material concepts with the world of entertainment in harmony (Ardianti et al., 2019; Feiyue, 2022). So, it can be concluded that edutainment is a process that combines concepts in education with learning entertainment in a harmonious way, making learning in class fun and making students enthusiastic about learning. As a result, edutainment makes students more secure, comfortable, relaxed, calm, happy, and not tense in learning in class (Siripipatthanakul et al., 2023; Septyaningrum et al., 2021). One of the edutainments is learning in tourist attractions or on rides, which can be analysed and associated with educational concepts. One of them is a tourist spot, namely GoFun Bojonegoro.

Bojonegoro is one of the regencies in East Java. Bojonegoro has many tourist attractions. One of them is Wahana GoFun Bojonegoro. GoFun Bojonegoro Rides are tourist attractions located on Jl. Veteran, Sukorejo, Bojonegoro District, Bojonegoro Regency, East Java. GoFun Bojonegoro is one of the attractive thematic tourist areas in Bojonegoro, which features a variety of exciting attractions and rides. GoFun Bojonegoro Theme Park is one of the many tourist rides that apply the concept of glasses in the presented game facilities (Nurvadilla et al., 2023). GoFun Bojonegoro offers a variety of rides ranging from the usual rides to rides that trigger adrenaline. Apart from rides, GoFun offers various games, swimming pools, and shopping tours. Both children and adults can play the rides and games at GoFun Bojonegoro. It also provides exciting attractions for children and adults (Kancanadana et al., 2021; Robbani, 2020).

The rides at GoFun Bojonegoro will later be selected, and some of the rides will be selected which can be analysed and taught to students as edutainment learning materials. This tourist destination in GoFun Bojonegoro is an actual situation, so contextual learning is rarely used in physics learning. Apart from learning new things about physics concepts at the nearby playground, they created a new, fun learning atmosphere (Hariyono et al., 2022). Some previous research confirmed physics concepts in particular playgrounds, such as Batu Night Spectacular (Ariantoro et al., 2021), Indonesian Fantasy World (Choirunnisa' et al., 2021), Lamongan Marine Tourism (Cahyani & Cheng, 2022), and Transmart Surabaya (Indriati et al., 2021). However, a study of the physics concepts contained in the GoFun Bojonegoro vehicle as learning material is still lacking. Therefore, this study aims to analyse the physics concepts in several rides at the GoFun Bojonegoro Theme Park.

RESEARCH METHOD

This study used qualitative descriptive research. Qualitative descriptive research means describing or describing in detail the problems studied in each individual or group at an event (Johnson & Christensen, 2014). This research focused on the rides by analysing how they work based on the physics concepts contained in the GoFun Bojonegoro Theme Park. The research stages carried out were: (1) Collecting references related to rides with physics concepts; (2) Observing the rides; (3) Selecting the vehicles to be studied; (4) Documenting the vehicles to be used; (5) Identifying physics concepts on rides; (6)

Analyse the physics concepts contained in the selected vehicles; (7) Formulate the results of the analysis study.

The following research stage is presented in Figure 1, where it is commenced from the identification of problems regarding the need for edutainment learning through the identification of physics concepts on the GoFun playground. After that, data was collected through observation, documentation, and analysis methods. Observations include visiting GoFun in Bojonegoro, documenting photos/videos, and reviewing some references. The collected data were then analysed for the interrelationship of physics concepts on the available vehicles by using descriptive qualitative. Finally, physics concepts can be formulated as a consideration in developing edutainment physics teaching modules.

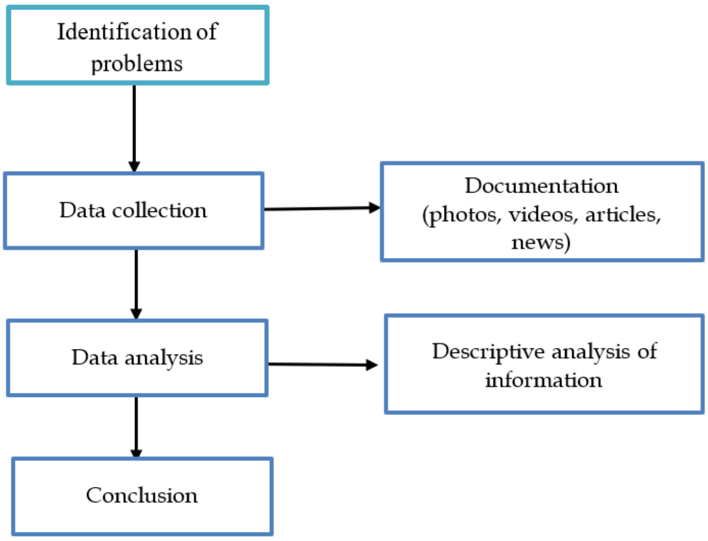

Figure 1. Research stage

RESULTS AND DISCUSSION

This research discusses the physics concepts contained in the GoFun Theme Park Bojonegoro vehicle. Based on existing games, we are interested in several games to study applied physics concepts, namely as follows.

Table 1. The concept of physics on the rides in GoFun Bojonegoro

Vehicle	Physics Concept	Information
Pirate Ship	Oscillation	The concept of oscillation stems from swinging back and forth through its equilibrium point at a certain angle.
Mini Ontang-Anting	Centripetal and centrifugal force	Centripetal force is the force towards the centre of the circle. Centripetal force takes the form of frictional force, gravitational force, and rope tension. Centrifugal force is the force that goes outside the centre of the circle.
Bom-Bom Car	Newton's 3rd law, collision, law of conservation of momentum, impulse	Newton's third law describes the action-reaction force. Giving an action force to an object also causes the object to give a reaction force, only in the opposite direction. Collisions or collisions are events when two or more objects collide. These events are followed by an exchange of forces at a specific time interval and fulfil the requirements of the law of conservation of momentum.

Vehicle	Physics Concept	Information
		The law of conservation of momentum reveals that objects before the collision and objects after the collision have the same momentum. The impulse experienced by an object is the change of momentum experienced by the object.

Pirate Ship

Pirate Ship is one of the rides in GoFun Bojonegoro that triggers adrenaline. This Pirate Ship resembles a *kora-kora* or swinging boat (Figure 2). As the name implies, this ride is like a swing boat that is made to face a certain height when swung. This vehicle also has a swing bench that hovers moderately fast and is in the air.

Figure 2. Pirate Ship Vehicle

The working system of the Pirate Ship is a deviation that occurs more than 90 degrees. The pirate ship moves with the help of the engine, which rotates on the tires that rub against the bottom of the boat. Initially, the pirate ship swung slowly to the right and the left, but after a while, it turned quickly to the right and left, even almost to the top (Figure 3).

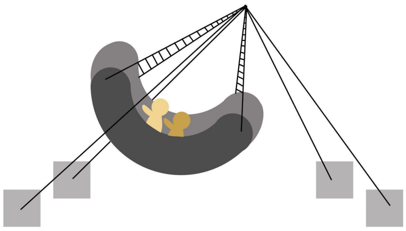

Figure 3. The replication of Pirate Ship

This pirate ship movement is a force that works with friction. When the pirate ship is swung to the right, it will be released and turned to the left due to the force of gravity. This is in accordance with the oscillation principle (Halliday et al., 2014). The movement of a pirate ship with mass (m) with an object suspended from a long rope (l) on a pole and then pulled up at a certain angle (θ) So this movement will swing back and forth. Oscillatory motion is a movement that is repeated (back and forth) within a certain time through its equilibrium point (Pratidhina et al., 2020). Oscillatory motion is described in Figure 4.

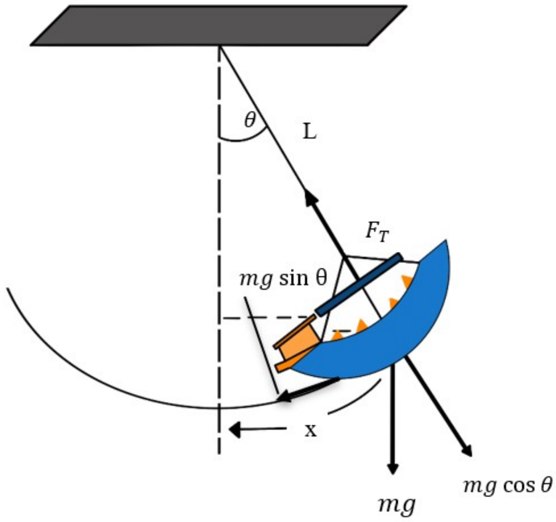

Figure 4. Oscillatory Motion

Based on the picture above, the oscillatory motion on the pirate ship is swinging regularly over and over again. Objects or benches are pulled with a particular angle deviation towards the top and then released. The object will swing to the right and left (back and forth) past the equilibrium point. The pirate ship vibrates harmonically if the swing amplitude is small (Arya, 1997). In general, equality oscillatory motion is as follows:

The centripetal force on the pendulum is:

$$F_s = -4\pi^2 m f^2 X$$

For the restorative force is

$$F = -mgsin\theta$$

Because θ small in size sinθ = θ. Thus, the restoring force equation:

$$F = -mg\frac{X}{l}$$

Because, centripetal force = restoring force, then

$$F_s = F$$

$$-4\pi^2 m f^2 X = -mg\frac{X}{l}$$

$$-4\pi^2 f^2 = \frac{g}{l}$$

$$f = \frac{1}{2\,p}\sqrt{\frac{g}{l}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Information:

F_s = centripetal force

F = Restorative force

l = arm length

g = gravitational acceleration

T = period of oscillation

f = frequency at corner

(Halliday et al., 2014)

This Pirate ship vehicle also applies centripetal force so that the object moves in a circle. But circular motion is only half a circle.

Mini Ontang-anting

Mini ontang-anting is one of the GoFun Bojonegoro rides (Figure 5). This vehicle is an extreme ride because it triggers an increase in the hormone adrenaline, characterised by speed and height. Mini ontang anting is shaped like a merry-go-round and almost similar to a swing but has a different height than the usual swing.

Figure 5. Ontang-Anting Mini Vehicle

Mini ontang-anting is a game with a focus on the centre. The centre is the axis of rotation. This game is hung with benches that differ from bench to bench (Figure 6).

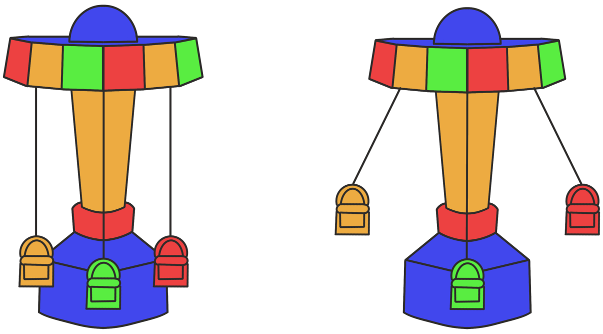

Figure 6. The Ontang-anting Mini Ride that was initially stationary (left) then moved around (right)

The mini ontang-anting is a bench that is hung at a certain height, rotates from the top, and then hovers in the air at a certain speed. The mini hoops move 360° in a clockwise direction.

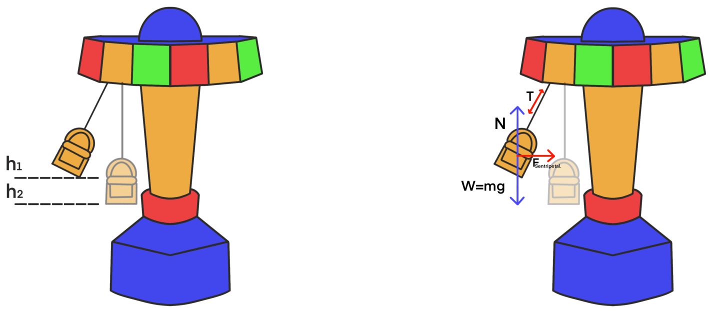

Figure 7. Changes in the seat height of the Ontang-Anting ride (left), The force that applies to the Ontang-Anting ride (right)

The existence of centripetal force makes the bench on the mini hoops continue to rise due to the centripetal force trying to pull the bench to the centre of the circle, namely the centre of the mini hoop at a certain speed and height. The mini ontang-anting bench always forms a certain angle to its plane (Ariantoro et al., 2021). This is what makes the centripetal force controllable and makes the bench move. The benches on the mini hoops are hung on a rope and then tied with an iron that connects the bench to the centre. The iron has a tensile force component, which is hung by a rope and then rotates. A pulling force exists between the ropes (Zhang et al., 2021). This tension in the rope produces circular motion and plays a role in the centripetal force (Pendril, 2020). Without centripetal force, the bench will rotate in a straight line in the plane's direction. Centripetal force takes the form of frictional force, gravitational force, and rope tension (Nurbaiti & Yusup, 2024). This force is in the form of gravity and rope tension that holds the load on the mini ontang-anting bench (Cahyani & Cheng, 2022; Choirunnisa' et al., 2021). So, it can be formulated as follows:

$$\sum F_s = m\frac{v^2}{R}$$

Because T =F_s , then the equation turns into:

$$T = m\frac{\omega^2}{R}$$

Information:
ΣFs = centripetal force (N)
T = rope tension (N),
m = object mass (kg),
ω = centripetal acceleration (m/s^2),
v = linear speed (m/s)
R = radius (m)

(Halliday et al., 2014)

In addition to the centripetal force, there is also a force always there, namely the centrifugal force. Centrifugal force has a direction that comes out from the circle's centre, namely the mini-bracelet's centre. The formula of the centrifugal force is the same as the centripetal force (Widia, 2023). However, this centrifugal force is apparent because the bench moves in a circle. Based on Newton's 1st law which states that if the force on an object will be 0, then there are 2 possibilities: the object will be at rest, and the object will move in a straight line. So, if an object is moving in a circle, the centripetal force is directed towards the center of the circle and the centrifugal force is away from the circle's centre. However, the fact that happens is that objects will still move. So, the centrifugal force is said to be a pseudo force (Holzapfel, 2024; Volfson et al., 2020).

Bom-Bom Car

Bom-bom car, better known as a bumpy car, is an arena in the GoFun Theme Park that applies the concept of collision (Figure 8). The nudge car moves due to electric grids at the top of the car that conduct electricity. The high electric power causes sparks, which are typical between the grid and the car's connecting rod. Sparks can be observed when the connecting rod is no longer connected or disconnected. Because the energy that is generated in each car is the same, causing cars with lighter passengers to move faster. According to Cahyani & Cheng (2022), the car is given a rubber belt so that when it crashes, it still feels comfortable because this rubber will absorb the effects of the collision. From these events, it can be concluded that when a car has mass m_1 and another car has mass m_2 collide with each other, it will cause a force, namely action-reaction which has the same magnitude but has a different direction, namely opposite each other (Newton's

III Law) (Choirunnisa' et al., 2021). If it is assumed that there are only forces generated in the form of action-reaction and there are no external forces that affect it, it can be written:

$$F_{12} = -F_{21}$$
$$m_1 . a_1 = -m_2 . a_2$$
$$m_1 . (IN_1' - IN_1)/t = -m_2 . (IN_2' - IN_2)/t$$
$$m_1 . (IN_1' - IN_1) = -m_2 . (IN_2' - IN_2)$$
$$m_1 . IN_1' - m_1 . IN_1 = -m_2 . IN_2' + m_2 . IN_2$$
$$m_1 . IN_1' + m_2 . IN_2' = m_1 . IN_1 + m_2 . IN_2$$
$$p_{1+}' p_2' = p_1 + p_2$$

Information:
F_{12} = force exerted by car 1 on car 2
F_{21} = force exerted by car 2 on car 1
m_1 and m_2 = masses of two different bumper cars
a_1 and a_2 = accelerations of the two cars
IN_1 and IN_2 = initial momenta of the two cars
IN_1' and IN_2' = final momenta of the two cars after the collision
t = time duration over which the collision occurs
p_1 and p_2 = momenta of the two cars

The equation shows that the effect of force objects, namely action-reaction or Newton's Third Law, creates the Law of Conservation of Momentum, which corresponds to sound in the law of conservation of momentum. The law of conservation of momentum reveals "when the force acting when two objects collide do not exist, then the object before the collision and the object after the collision have the same momentum" (Rohman et al., 2020). In the car bomb rides, it can also be seen that impulse is a change in momentum, so if the speed of the first car changes from before the collision to after the collision and the speed of the second car changes from before to after the collision, the following applies:

$$m_1 IN_1 + m_2 IN_2 = m_1 IN_1' + m_2 IN_2'$$

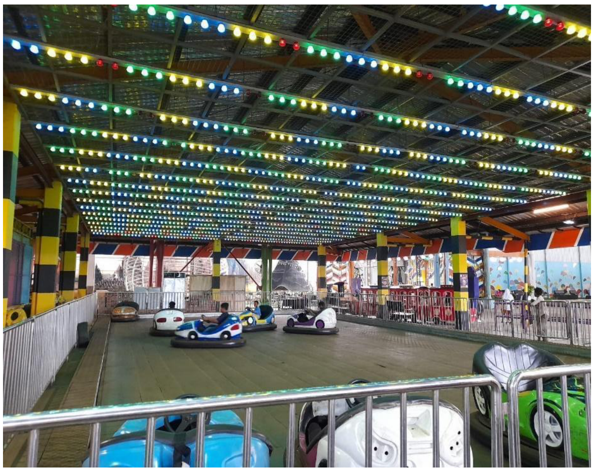

Figure 8. Bom-Bom Car Vehicle

The car bombs not only apply the concept of collisions but also apply concepts from Newton's third law, the law of conservation of momentum and impulses (Cahyani & Cheng, 2022). Furthermore, the teaching materials from this research can discuss the impact of physics analysis on game vehicles, which can be an exciting and educative topic for students (Shute et al., 2021; Arzak et al., 2021). On the ontang-anting ride, there are the physics concepts of centrifugal force, circular motion, and oscillations. The car bomb rides contain the physics concepts of Newton's third law, collisions, the law of conservation of momentum and impulses. Integrating physics learning with vehicles or edutainment makes learning more fun because it combines and analyses the physics concepts contained in the vehicle. This can help students understand how physics concepts are applied in everyday life (Sharon & Baram-Tsabari, 2020), especially in the design and function of rides.

Generally speaking, there are three main physics concepts in GoFun playground: pirate ship, mini ontang-anting, and bom-bom car. The pirate ship vehicle contains the concept of oscillatory motion, the mini ontang-anting contains the concept of centrifugal and centripetal force, and the bomb-bomb car contains the concepts of newton's 3rd law, momentum, and impulse. These three vehicles can be a means of edutainment for students who want to learn physics outdoors. The implementation of edutainment-based learning has a positive influence on physics learning, as reported by some empirical studies (Ardianti & Wanabuliandari, 2021; Astra et al., 2024; Fülöp et al., 2017; D. Indriati, 2012; Irawati et al., 2008).

CONCLUSION

Fundamental Finding: GoFun Bojonegoro is one of the area edutainments in Bojonegoro, which has rides for games and entertainment with an attractive appeal for visitors. Some of the rides available at GoFun Theme Park Bojonegoro have interesting physics concepts to learn about. Based on the results of the discussions and discussions that have been carried out, the vehicle pirate ship is a physics concept about oscillations. On the ontang-anting ride, there are the physics concepts of centrifugal force, circular motion, and oscillations. The car bomb rides contain the physics concepts of Newton's third law, collisions, the law of conservation of momentum and impulses. Integrating physics learning with vehicles or edutainment makes learning more fun because it integrates and analyses the physics concepts contained in the vehicle. **Implication:** It is hoped that based learning edutainment can increase students' effectiveness in understanding physics concepts, make students more active, and make learning fun. **Limitation**: The present study only focused on analysing three vehicles, and other vehicles may have potential physics concept to be explored. **Recommendation**: While future researchers can further explore and analyse physics concepts in different vehicles, the results of this research can be actualised in a physics learning module that contains entertaining phenomena so as to create fun and enjoyable physics learning environment.

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