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Exploration of Physics Concepts in Game Vehicles in the Indonesia Fantasy World

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ABSTRACT

Edutainment in physics learning or also known as physics-edutainment is a physics learning strategy associated with entertainment. The purpose of this article is to explore the physics concepts contained in the Indonesian Fantasy World. The research was conducted by studying literature from various sources of supporting articles. This study uses a qualitative descriptive approach, while the type of research used by the researcher is library research. Data or information in the form of articles obtained, then analyzed according to the content or purpose of each article. The data obtained is that there are 6 game rides that have been explored, including the Kora-kora, Bianglala, Halilintar, Ontang-anting, Zig-zag, and Hysteria rides which have physics concepts in the techniques used when moving them.

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INTRODUCTION

Learning is an activity that requires a lot of time, besides that it also takes energy and thought, so that not a few people will experience boredom in doing it. That way, to relieve stress and boredom in learning can be released by visiting entertainment places (Nuriyana, Hendra, and Laksono 2021). Recreation and entertainment are important components of everyday life. The density of activities carried out by the community and many needs that must be met so that they experience saturation and stress. The entertainment center is their place of solution, so it becomes a place that is often visited by people from all walks of life (Mubarak and Aqli 2021). In relation to the two, namely entertainment and learning, there are learning strategies that can be used, including Edutainment.

In the teaching strategy, Edutainment is packaged in the form of entertainment, so it can be said that Edutainment is a fun learning strategy with the aim of educating and entertaining (Haryadi, 2017). While in Edutainment there are several categories, namely digital communication technology, social media, and the internet (Winarti, Yuliani, Rohmadi, & Septiana, 2021). So learning that uses between these categories shows the implementation of the Edutainment learning strategy. With this utilization, one of them is Techno Park. Techno Park is a land that was deliberately built with the aim of being a center for science and Research and Development (R & D) with an attractive architectural building. (Meutia, Sujadmiko, & Pratiwi, 2017).

Edutainment in physics learning or also known as physics-edutainment is a physics learning strategy associated with entertainment. The entertainment referred to here is physics learning which is expected to be able to give a pleasant impression so that it can attract students' interest to learn it. According to research conducted by (S, Edhi, & Sukisno, 2014) which shows that learning using physics-edutainment techniques can improve student learning outcomes. That way, based on the existing components in edutainment, there is a technology

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that can be used, namely Techno park. With the existence of the Techno park, it can be used as a source of knowledge that examines the concept of physics. For example on the Dunia Fantasi (Dufan) Ancol Indonesia vehicle. Dufan itself is the largest physics edutainment area in Indonesia that has rides for games and entertainment that can spoil the eyes of visitors, such as Fantasy Around the World. Dufan also has nine high-tech rides, such as parts of Indonesia, Asia, Europe, America, Greece, Hikayat, Kalila and Fantasy Lights (Mubarak and Aqli 2021) With the Dufan vehicle, researchers expect that some of the games contained in it can be studied with the concept of physics.

There are already quite a number of tours in Indonesia that have educational concepts on several rides in them that aim to attract the attention of visitors. As in the research conducted by Rahmatin & Mahagangga (2016), where it is stated that East Java Park or JTP tourism has combined the concepts of education and entertainment at the same time, so that it has uniqueness and new innovations that present its museum tourist attractions so that it can give unforgettable meaning during the trip. In Estherlita's Gosal & Karongkong (2017) research, mentioned that the Planetarium and Observatory area in Indonesia does not only have an educational concept, but also a tourism concept, so that we can travel while learning. And in Suwakdi's Inderawati, & Lie (2015) research, stated that Dufan is also one of the central edutainment areas in Ancol, namely the opening of Fantasy World Physics (Fidufa) and Performance Performances. Dufan Indonesia has various rides for games and other entertainment, such as roller coasters, Bianglala, and Kora-kora.

The game rides at Dufan Indonesia have an interesting physics concept in it which is interesting to learn. Some of these physics concepts have been described in the research (Ristiani, Pakro, Nurfitriyah, & Pertiwi, 2018), where the relationship between the roller coaster ride with the concept of physics is the presence of mechanical energy. Then for other vehicles such as the kora-kora motion caused by the physics concept of simple harmonic motion such as oscillation. The motion of the devil's barrel and the Ferris wheel is caused by the physical concept of the centripetal force which is directed towards the center of the axis. There are also game rides such as ontang-earring whose movement is caused by physical concepts in the form of centrifugal force and centripetal force acting on an object that moves in a circle (Kusuma, 2018).

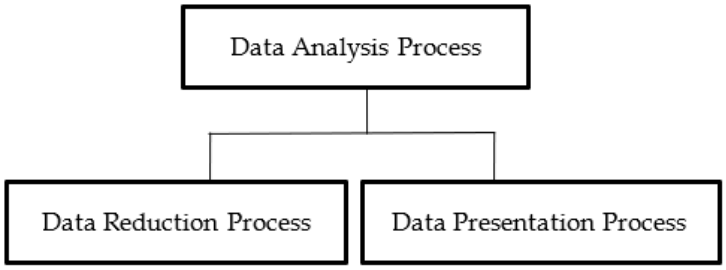
Based on this background, the purpose of this article is to explore the physics concepts contained in the Indonesian Fantasy World vehicle. The research was conducted by studying literature from various sources of supporting articles.

RESEARCH METHOD

This study uses a qualitative descriptive approach, while the type of research used by the researcher is library research, where the researcher collects data or scientific papers related to the topics raised in library research (Lestari, Hamdan, and Susilawati 2021). This technique is known as literature study. Literature studies are carried out by starting from the data collection process in the form of articles or journals with appropriate and predetermined topics. Data collection is done by collecting secondary data as a reference source and reports from accurate sources such as Google Scholar.

Data or information in the form of articles obtained, then analyzed according to the content or purpose of each article. The process of data analysis in this study was carried out in two stages as shown in the following diagram:

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1. Data Reduction Process

The data reduction process is a process carried out to make it easier for the author to choose data that has been taken from various sources.

2. Data Presentation Process

The process of presenting data is the process of rewriting the results of the analysis of all data written in narrative form.

According to (Rachmawati & Supardi, 2021) the library research method is a method that can be used by searching for relevant and sustainable literature sources with the topics to be discussed, so that the predetermined goals can be achieved by finding scientific and theoretical studies. This library source is used to obtain research data, accurate references obtained using Google Scholar. The data was obtained by using the keywords "edutainment" "technopark" and the required physics concepts. Then the range of article data used is from 2012 to 2022 with a total of 30-40 article data.

RESULTS AND DISCUSSION

In this study, we will discuss the physics concepts contained in the vehicle in Dufan Indonesia. Based on the existing vehicles, we are interested in several vehicles to study the physics concepts used. Are as follows :

Name	Physics Concepts	Information
Kora kora	Centripetal Force, Oscillation	Kora kora or swinging boat is one of the extreme rides that uses the concept of oscillating motion. The vehicle moves with both ends of the vehicle reaching a certain angle under the centrifugal force.
Bianglala	Circular Motion, Centripetal Force, Gravitational Force	A Bianglala is an object that rotates about its axis, so each part of the object moves in a circle centered on the axis. Centripetal acceleration is the acceleration that occurs in uniform circular motion whose direction is always towards the center of the circle. Where the centripetal acceleration is caused by the centripetal force. The rotating cabins on the Ferris wheel will remain upright due to the influence of gravity.
Halilintar	Centripetal force, kinetic energy-potential energy (Mechanical Energy)	Lightning is one of the vehicles that uses several physics concepts, including the potential energy contained at the top of the trajectory and is zero when it is at its lowest position, as well as kinetic energy in the centripetal force, when the lightning moves on a circular path, this force "maintains" the lightning. to keep moving. The combination of kinetic energy and potential energy that exists produces mechanical energy

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Name	Physics Concepts	Information
Ontang Anting	Centrifugal force, Circular motion, Oscillation	Ontang anting are in The Swing arena, there is a concept of centrifugal force on the passenger seat when the vehicle starts to move. That way the angle made by the chair with the vertical line is getting bigger
Zig-Zag	Friction, Collision, Law of Conservation of Momentum	The Zig-Zag ride or Bomb-bom car is a game vehicle that has the concept of collision physics. When a light passenger car is hit by a heavy passenger car, the light passenger will feel thrown. This is in accordance with the law of conservation of momentum. And this moving car will experience friction with the floor.
Hysteria	Pneumatic Gravity Force	Hysteria is a vehicle that uses the physics concept of pneumatic gravity. The Hysteria can transport 500 people with its ultra-fine pneumatic gravity at speeds of up to 4G, which are dropped at high speed later.

1. The concept of physics on the kora-kora vehicle

Kora-kora is one of the rides in the Fantasy World or often called Dufan. Dufan is a place that is visited by quite a lot of people, from children to adults. Likewise with the kora-kora ride, this vehicle has its own charm. With various reasons to be able to ride in these rides, one of which is that you can ride it together with group friends. Here is an overview of the kora-kora ride.

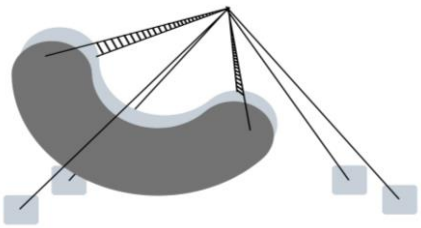


Figure 1. *Kora-kora* ride replication

The boat-shaped ride has a capacity of 36 people. In addition to being a tourist attraction, it turns out that if you pay attention and analyze the Kora-Kora vehicle there is a concept of physics. The working system on the kora-kora vehicle is the working system of the pendulum, where the deviation is more than 90 degrees. The movement on the kora-kora vehicle is carried out by a machine, it can be said to be a force acting on the kora-kora by friction. Kora-kora move for 3 to 4 minutes by moving up by the help of rotation on the tires rubbing against the bottom of the boat driven by the engine. At first it moves slowly, then it will swing faster. At the time after being pulled, kora-kora movement is released due to gravity. On the working principle of the pendulum, the motion on the kora-kora vehicle is the mass (m) of the object suspended by the rod which is then pulled up (deviated) at a certain angle of \theta. This back and forth swinging motion is also known as oscillation. Oscillation motion is motion repeatedly with time on an object or also with a mechanical system through an equilibrium point (Budi, 2015). The oscillatory motion can be described as follows:

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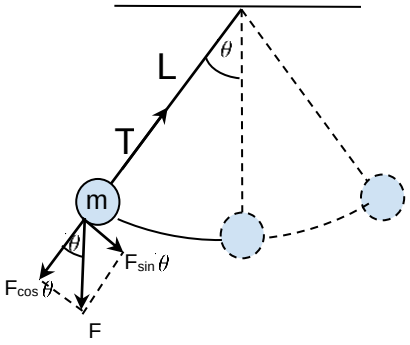


Figure 2. Oscillation motion

The oscillatory motion of the kora-kora moves or swings repeatedly as depicted in the illustration, where the object is pulled up with a deviation at a certain angle and released. So, the object swings back and forth, what distinguishes it from the kora-kora vehicle is that which regulates the movement of the machine. So when it is formulated with the general equation for oscillatory motion as follows:

$$\frac{d^2\theta}{dt^2} + \omega^2\theta = 0$$

$$\omega^2 = \frac{g}{L}$$

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

Where T is the period of oscillation, \omega is the frequency at the angle, L is the length of the hanging rope and g is the speed of gravity (Budi, 2015). From these equations, it shows that the length of the hanging rope affects the magnitude of the resulting period, so that in making the vehicle it must be correct in the calculations. Because when in the calculation process there is an error, the possibility of an accident occurs. Therefore, before the vehicle is opened to the public, the engine is usually tested first, so as to minimize casualties.

2. The concept of physics on the Ferris wheel

The Ferris wheel in Dufan Indonesia is a large Ferris wheel with a height of ± 30 meters above sea level, and a capacity of 180 people. This ride is certainly suitable to be enjoyed with family, friends, friends and relatives. Although it can be enjoyed at any time, it is preferable to enjoy this ride in the afternoon because in addition to enjoying the beach view from the highest height, they can also enjoy the romanticism of the setting sun which alternates with the sparkling lights of the Ancol Dreamland Park. Here is an overview of the Ferris wheel:

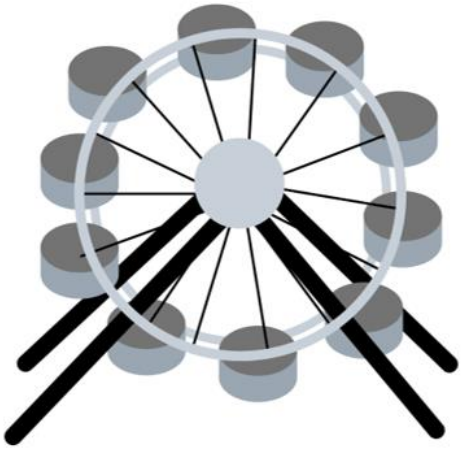


Figure 3. *Bianglala* ride replication

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A Ferris wheel is a wheel-shaped wheel on which the passenger cabins are attached to the rim so that when the wheel rotates, the cabin remains upright, usually thanks to the force of gravity. The cabins which rotate about their axis move in a circle centered on the axis. Centripetal acceleration is the acceleration that occurs in uniform circular motion whose direction is always towards the center of the circle. According to Newton's law, the cause of an object to move with an acceleration is a force. The force that causes the centripetal acceleration is called the centripetal force (Yusuf & Indratno, 2017); (Ristiani, Pakro, Nurfitriyah, & Pertiwi, 2018). So that the Ferris wheel has physical concepts, namely circular motion, centripetal force, and gravitational force.

The equation of circular motion on the Ferris wheel can be written as follows:
The angular velocity is:

$$\omega = \frac{2\pi}{T} = 2\pi f$$

The linear velocity is:

$$\omega = \frac{2r\pi}{T} = 2\pi r f$$

or

$$v = r.\omega$$

And for the acceleration value is:

$$a = \omega^2.r = \frac{v^2}{r}$$

(Yusuf & Indratno, 2017).
From this equation, it can be seen that a Ferris wheel can continue to rotate or move in a circle and is centered on its axis due to the centripetal acceleration, which is influenced by the angular velocity or linear velocity of the Ferris wheel movement and also the radius of the Ferris wheel. This needs to be known so that the vehicle can run well.

3. The concept of physics on the Lightning vehicle

Lightning is one of the extreme game rides in Dufan and we usually know it as the Roller Coaster. Halilintar itself sits in pairs by extending the back + - 12 seats with a total of 24 passengers. The track on this game is tortuous and turns upside down at high speed to stimulate the adrenaline of tourist visitors. Dufan himself deliberately made one round and no more on the lightning game, because the Halilintar operator who was with Dufan emphasized that the health conditions of each passenger were not the same. Dufan's own party has taken into account the security and safety of visitors by not extending the duration of the round of lightning. As for some of the rules that exist in this game vehicle, namely:

- Pregnant women;
- Tb < 125 Meters;
- Suffer from heart disease, epilepsy and also stroke.

This lightning moves in the direction of the provided rail at high speed, while the physical concepts used are mechanical energy (kinetic energy-potential energy), and centripetal force. Mechanical energy itself is a total of energy both at rest and in motion from kinetic energy and potential energy (Saputro 2018)

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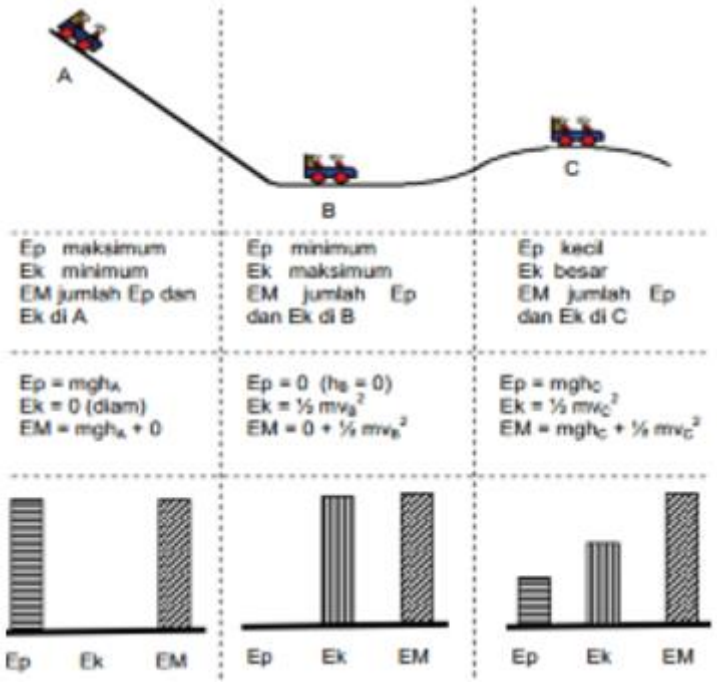


Figure 4. Energy transfer chart on roller coaster or *Halilintar* (Saputro 2018)

Figure 4 depicts a graph of the energy transfer that occurs on a roller coaster. In (Saputro 2018) states that based on the theory of work and energy, the mechanical energy of lightning is not only influenced by the position or state of the trajectory but also by friction.

If W in the compressive force of the object moving in a path with a friction coefficient of , then the magnitude of the frictional force is :

$$F_{ges} = \mu W$$

If there is relative motion between two surfaces, the frictional force is called kinetic friction. The kinetic friction force itself has a direction opposite to the direction of the object's movement so that the object is getting longer and slower.

Based on the graph of the tool in Figure 1, it can be seen that the value of mechanical energy at position A is the same as mechanical energy at position

$$BEM_A = EM_B$$

Meanwhile, the kinetic energy at A is zero and the potential energy value at B is also zero so that the value of the potential energy at A is equal to the kinetic energy at B.

$$Ep_A = Ek_B$$

with, $Ek_B = \frac{1}{2}mv^2$. Furthermore, by paying attention to the movement of objects on the trajectory using Uniformly Changing Straight Motion (GLBB) it can be obtained :

$$v = v_0 + at$$

Since the object is not given an initial velocity then v_0 is zero. Next, we substitute equation (4) into equation (3) to produce equation:

$$a^2 = \frac{2Ek}{mt^2}$$

where m is the mass in kilograms and t is the time taken by the lego car in seconds. For more details, you can see an example of a lightning image below :

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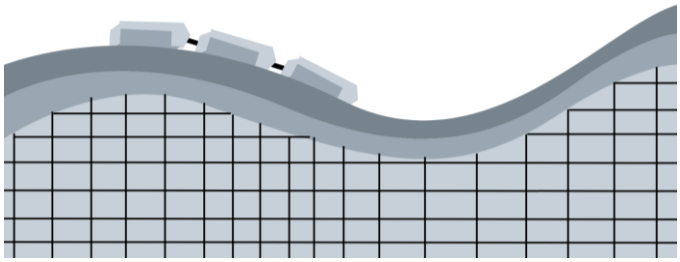


Figure 5. Roller coaster ride replication

It can be concluded from the statements above, it can be seen that the lightning vehicle or Roller Coaster in Dufan Indonesia has the concept of kinetic-potential energy and also centripetal force.

4. The concept of physics on the Ontang-Anting ride

Ontang anting is one of the extreme rides in Dunia Fantasi, because the rides rotate at a certain speed and height so that they are quite popular with visitors. With a lot of capacity, earrings are often used as a challenge for visitors and their group of friends. Here is an overview of the vehicle:

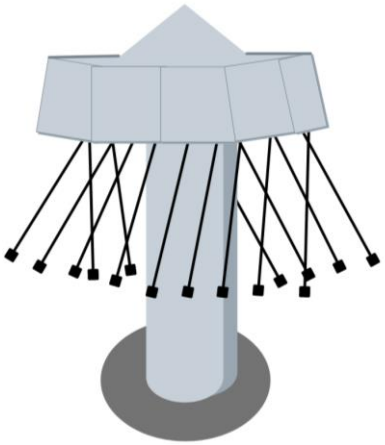


Figure 6. Ontang-Anting ride replication

Rides with chairs that are hung in the center that is given a distance between one seat to another. When the engine is started, the chair will move around. In circular motion, there is a centrifugal force acting in a direction towards the center of the circle. With this style, make the chairs move around. The chair on the earrings is hung by an iron that connects the seat to the center. In iron, there is a tension force component or if it is illustrated on an object that is hung by a rope and then moved in a rotating manner, there is a tension force in the rope. It is this stress that plays a role in the centripetal force, resulting in a circular motion (Nasution & Rahmawati, 2019). So when it is formulated as follows :

$$\Sigma F_{sp} = m \, . \, a_{sp}$$

$$\Sigma F_{sp} = \frac{m \, . w^2}{R}$$

Because T = F_{sp}

Then,

$$\boldsymbol{T = \frac{m \, . w^2}{R}}$$

Where, ΣF_{sp} is the centripetal force (N), T is the tension in the string (N), m is the mass of the object (kg), a is the centripetal acceleration (m/s^2), v is the linear velocity (m/s) dan R is the radius (m).

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But not only moving around, visitors will feel a sense of being pushed outward. This phenomenon is the effect of centrifugal force. The similarity between centrifugal force and centripetal force is that they both act on objects moving in a circle. It should be noted that the centrifugal force actually does not, this is because it is only a pseudo effect that is caused when there is an object moving in a circle. Based on Newton's first law which states that there is a net force on an object, the object is at rest or moving at a constant speed along a straight line. So if there is an object moving in a circle, the centripetal force is directed towards the center of the circle and the centrifugal force is away from the center of the circle. However, the fact that happens is that objects will still move. So the centrifugal force is said to be non-existent (Kusuma, 2018).

5. The concept of physics on the Zig-Zag rides

Zig – Zag is a ride for a "family" consisting of several electric powered cars. This ride is played by directing the car to avoid other cars. Zig-Zag is also often referred to as bom-bom car. Here is an overview of the Zig-Zag rides or bom-bom car:

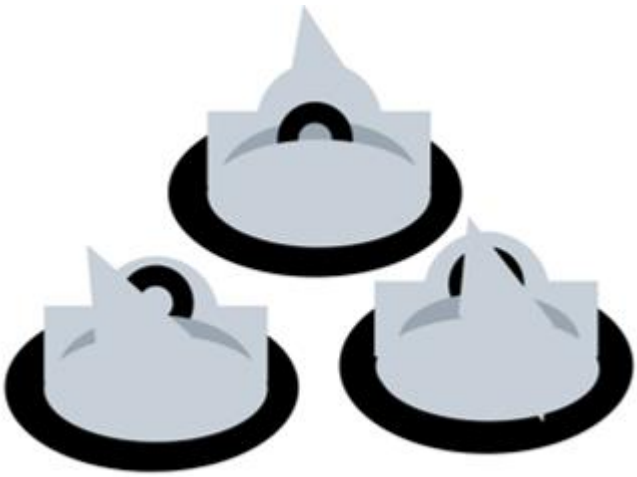


Figure 7. Zig-zag ride replication

These bom-bom car have a physical concept, namely the collision concept. When a light passenger car is hit by a heavy passenger car, the light passenger will feel thrown. This is in accordance with the law of conservation of momentum. And a car that continues to move will experience friction with the floor. The law of conservation of linear momentum states, "In a collision, the total momentum of the system just before the collision is the same as the total momentum immediately after the collision, provided that no external force acts on it." The collision itself consists of a perfectly inelastic collision, a partially elastic collision and a completely inelastic collision (Rezeki & Ishafit, 2017).

When two bom-bom car collided with each other, there was a bounce between the cars but there was no accident. In a car bomb car, rubber tires are installed at the bottom to reduce the number of collisions between cars. So the car will bounce when it collides, and the rubber tires will absorb the impact, where the collision before and after the car collides will be the same.

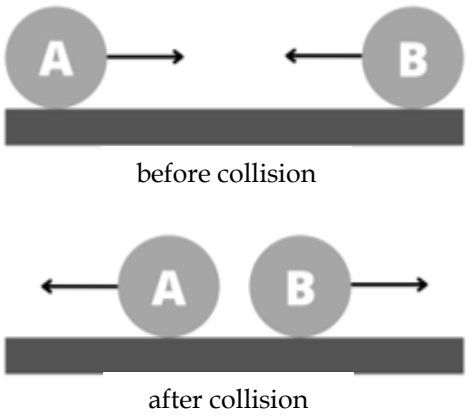


Figure 8. The process of collision

If it is analogous to two balls colliding, where the velocity of the ball on the left (A) changes from before the collision to after the collision and the velocity of the ball on the right (B) changes from before the collision to after the collision, it can be written mathematically as follows:

$$m_A.v_A+m_B.v_B = m_A.v_A'+m_B.v_B'$$

Where the equation is the equation of the law of conservation of momentum, which can also be written as follows:

$$\Sigma P_{sebelum} = \Sigma P_{sesudah}$$

where P = m.v , m is mass and v is velocity (Wantoro, Sudjito, & Rondonuwu, 2016).
So from the statements above it can be seen that a car bomb vehicle in Dufan Indonesia or known as the Zig-Zag vehicle has the concept of a collision when two cars hit each other, where the total momentum before the car collides is the same as the total momentum after the car collides, which is in accordance with the sound of the law of conservation of momentum.

6. The concept of physics on the Hysteria rides

Hysteria is one of the rides located at Dunia Fantasi Ancol, Taman Impian, Jakarta, which is supported by advanced technology and is the highest vehicle and has the largest capacity in Indonesia, originating from the United States. Hysteria consists of 2 (two) towers with a height of 56 meters and has a capacity of 12 seats per tower. This Hysteria ride is capable of carrying around 500 passengers/hour. And at Hysteria, visitors can stimulate adrenaline and feel the sensation of being thrown up with a very smooth pneumatic movement at speeds up to 4G, then dropped back at a speed of minus 1 G.

The load received by the pneumatic cylinder consists of several component loads, including other pneumatic cylinder loads and products. The object's load can be known through the equations of force (F), mass (m), and gravity (g) (Nugroho, Karuana, and Kristiawan 2021).

$$F = m \times g$$

Calculation of pneumatic cylinder diameter requirements with the equation of force (F), working pressure (P), and cross-sectional area (A).

$$F = P \times A$$

So from the statements above, it can be seen that a hysteria vehicle in Dufan Indonesia has the concept of a collision when the vehicle rises upwards and suddenly falls downwards.

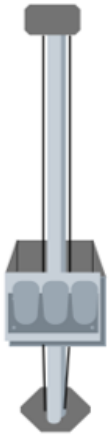


Figure 9. Hysteria ride replication

CONCLUSION

Dunia Fantasi (Dufan) Ancol Indonesia is one of the largest edutainment areas in Indonesia that has rides for games and entertainment that can spoil the eyes of visitors. Some of the rides available in Dunia Fantasi Indonesia have interesting physics concepts to learn. Based on the results and discussion above, it can be concluded that there are 6 rides that we have explored the concept of physics in the techniques used in moving each vehicle, including the kora kora vehicle which has the physics concept of Centripetal Force and Oscillation. On the Ferris wheel there are the concepts of Circular Motion, Centripetal Force, and Gravity Force. On the Lightning vehicle, there are physical concepts of centripetal force, and kinetic energy-potential energy (mechanical energy). On the Ontang Earrings vehicle there are physical concepts of centrifugal force, circular motion, and oscillation. In the Zig-Zag vehicle there are physical concepts of Friction, Collision, and the Law of Conservation of Momentum. And on the Hysteria spacecraft there is a physics concept of pneumatic gravitational force.

Exploring the rides in Dunia Fantasi Indonesia is an edutainment learning that can be applied to students. So that learning is more fun by integrating the concept of a vehicle that is in great demand by the community into learning. For further research, it can be done by examining the concepts of physics in other vehicles. So that Edutainment learning can continue to develop in the community.

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