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Analysis of Physics Concepts in Adrenaline Games in the Batu Night Spectacular (BNS) Area

***Mohammad Bakhit Mufti[1], Lely Mutakinati[2], Nadia Dewi Masithoh[1]**
[1]Universitas Negeri Surabaya, Indonesia
[2]Sizuoka University, Japan

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ABSTRACT

Adrenaline games are often found in amusement parks, because adrenaline games are one of the keys to attracting people's attention. Indonesia has many entertainment venues spread across various regions. One example of an amusement park in Indonesia is Batu Night Spectacular (BNS). BNS is one of the tourist sites in the city of Malang, East Java, to be precise in the city of Batu. This study aims to analyze the concept of physics in adrenaline games at BNS. The games that will be analyzed are Mega Disco, Crazy Bike, Drop N'Twist, and Gravitron. This research is a qualitative descriptive research using literature review and observation methods. Based on the literature review and observations that have been made, it was found that in the Mega Disco game there is a physics concept of oscillatory motion and rotational motion. Rotational motion is shown by repeated movements to the right and left, while rotational motion is shown in the rotation experienced by visitors' seats. In the Crazy Bike game there is a simple pendulum physics concept and circular motion. A simple pendulum is shown in a swinging motion with a connecting arm, while circular motion is shown in a crazy bicycle swinging 360 º . In the Drop N'Twist game, there are concepts that are free fall and vertical upward motion. The Gravitron game has the main concept of three forces that occur, namely gravity, frictional force, and normal force. Gravity is influenced by gravity on a band, and frictional force opposes the motion of gravity so that visitors don't fall down . normal motion is towards the center to maintain the visitor's position while the gravitron rotates.

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INTRODUCTION

Playing activities make the feeling of being happy, joyful, and full of joy for those who do it. In addition, playing activities will develop cognitive, social, physical and emotional use towards adult growth. Play activities are scientifically proven to support children's development in learning and adapting to the development of their senses (Popov, 2006; Gabdrakhmanov et al., 2016). Everyone has the right to engage in play activities from children to adults. Adults need to do play activities. Play activities provide opportunities for social interaction and are spaces for conveying emotions, such as laughing and screaming (Wang et al., 2017; Johra et al., 2021).

Sometimes a game not only gives the impression of being happy and excited, but can also give a tense impression that will trigger a surge of adrenaline in the body. These games are usually called adrenaline games (Haverlíková, 2011; Suprapto & Mubarok, 2020). Medically speaking, adrenaline is called epinephrine. Epinephrine is a hormone that is released in response to stressful situations. Adrenaline surges can be in the form of irregular breathing, increased energy expended, and increased heart rate.

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In the 80s, America created various adrenaline games. The rides are an experimental project from the Centrifugal Research Institute (ICR), Florida under the name Centrifuge Brain Project. The researchers developed the idea to build rides inspired by children's playgrounds, such as the Spherothon and The Wedding Cake rides. The Spherothon ride was the first centrifugal project in 1982. Meanwhile the Wedding Cake ride was designed in 1985. Another ride, the Steam Pressure Catapult ride, is a ride that gives the impression of being thrown with a slingshot, this ride was built in 2003.

Adrenaline games are often found in amusement parks, because adrenaline games are one of the keys to attracting people's attention. An amusement park is an ideal place to do a physics experiment that cannot be done in class. An amusement park can be said to be a giant physics laboratory. A wide variety of games are offered at the amusement park including adrenaline games. All the games in the amusement park apply physics concepts (Miller & Twum, 2017; Nichols et al., 2016).

Physics is a branch of science which incidentally is easy to find in everyday events. Everyday events are formed due to the interaction of various physical quantities in forming symptoms in life (Suprapto et al., 2021; Mavhunga & Kibirige, 2018). One of the daily events is on a game vehicle. For example, in roller coasters, roller coasters are not operated using machines. Roller coasters that can dive, slide and spin very fast basically only by utilizing the force and potential of gravity (Afrianto, et al., 2018). In game rides, when in a loop visitors will not fall because there is a centrifugal force that is able to offset the weight due to the pull of the earth's gravitational force (Suprapto et al., 2021). Another example is the Ferris wheel game. The Ferris wheel is a giant Ferris wheel that rotates at a certain time and gives the sensation of height by going up and down, and so on. The rotation of the Ferris wheel applies the concept of physics, namely the concept of circular motion or rotational motion (Arzak et al., 2021; Indriati et al., 2021).

Indonesia has many entertainment venues spread across various regions. Along with technological developments, amusement parks in Indonesia are increasing and developing with their innovations (Indriati et al., 2021; Dean, 2021; Keller, 2017). One example of an amusement park in Indonesia is Batu Night Spectacular (BNS). BNS is one of the tourist sites in the city of Malang, East Java, to be precise in the city of Batu. As the name implies, BNS only operates at night. BNS consists of places for games, sports, shopping, and other entertainment. At first BNS was an ordinary night market which transformed into a modern night market with the times. At BNS there are many rides for adrenaline games which are one of the attractions of the community, namely, flying swinger, Drop N' Twist, Megamix, Crazy bikes, Gravitron, etc.

Based on the description above, this study aims to identify the physics concepts that are applied in adrenaline games in the Batu Night Spectacular (BNS) amusement park. With this research, it is hoped that it can increase public knowledge about the applications of physics concepts in everyday life.

RESEARCH METHODS

This research is a qualitative descriptive study. Descriptive research aims to objectively interpret an object related to research variables in the form of words or numbers (Sugiyono, 2020). This study used a qualitative approach with data collection, data interpretation, and data presentation described in a narrative manner.

Data collection techniques were carried out through literature review and observation Literature review is a research method by developing theoretical studies from valid sources related to the concept of an event with the aim of reinforcing conceptual ideas. The researcher conducted an indirect observation by observing the BNS adrenaline game through trusted media to obtain data. The research was conducted by observing objects in the form of adrenaline games at Batu Night Spectacular (BNS). This research involved four adrenaline games at Batu Night Spectacular (BNS), namely mega disco, crazy bike, drop N'twist, and Gravitron.

The stages in the research were to make an observation through several journals and video events on the four adrenaline games, then based on these observations the physics concepts in

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adrenaline games were analyzed and described by conducting a literature review related to physics concepts and observations on adrenaline games.

RESULTS AND DISCUSSION

This study discusses the concept of physics in adrenaline games at Batu Night Spectacular (BNS). This research will discuss several adrenaline games which will be analyzed for their physics concepts. The adrenaline games that will be analyzed are Mega Disco, Crazy Bikes, and Gravitron games.

Mega Disco



Figure 1. Mega Disco, Batu Night Spectacular (BNS)'s newest ride that drives adrenaline. *(Photo: Eko Sabdianto/malangNEWS)*

This mega disco game is almost the same as the adrenaline game, namely the kora kora ship. This vehicle gives a thrilling sensation through swinging movements to the right and left. The concept of physics that occurs in the mega disco game is oscillatory motion and rotational motion. Oscillatory motion is shown in repeated movements at two points, while rotational motion is shown in the rotating movement of the passenger seat together with the oscillation motion. The magic disco game moves/oscillates using a machine, so that the movement is regulated by the machine and the paths traversed are limited according to what has been made.

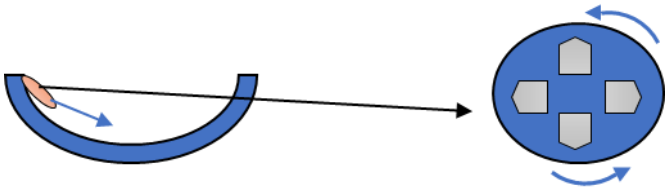


Figure 2. Illustration of the movement in the mega disco game

Oscillatory motion is a back-and-forth motion between two points involving force and energy. In Newton's first law, it states that an oscillating object shows the influence of a force . Without a force , the object will move in a straight line at a constant speed. In the mega disco game, the train is driven by an engine, the engine acts as a force for the train. On the path used, the position of equilibrium is at the top of the valley. When the train moves away from the equilibrium point and reaches the maximum deviation, the train will experience a restoring force, namely the tendency of the object to return to its stable equilibrium point. However, by the time it reaches that point, the train gains momentum and continues to move past the equilibrium point and undergoes the opposite deformation. This process will continue until the dissipative force dampens the motion.

Periodic motion is motion repeated at certain time intervals. This is shown by the movement of the mega disco train which repeats itself and will stop within a certain time. In periodic motion there are terms period and frequency. The period shows the time used for one isolation, while

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the frequency shows the number of oscillations per unit time. The relationship between the two is stated in the equation f = 1/T.

Mega disco game is a simple harmonic oscillator. A harmonic oscillator is an oscillatory motion that moves with the same displacement on both sides of the equilibrium (openstax, 2016). This is indicated by the trajectory used in the form of a semicircle with the equilibrium point at. valley floor . The maximum displacement from equilibrium is called the amplitude (openstax, 2016).

Based on the mega disco track, the amplitude is indicated by the track boundaries. The amplitude does not affect the frequency and period values. In a simple harmonic oscillator, the period and frequency values are determined by the following equation

$$T = 2\pi\sqrt{\frac{m}{k}}$$

It is known that f = 1/T so that the frequency value is

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

When it oscillates and there is speed, the object has kinetic energy (EK = ½ mv ^{2}). Whereas if there is only a position then the object has potential energy (EP = ½ kx ^{2}). So that for the total energy of an oscillating object is

$$EM = \frac{1}{2}\,mv^2 + \frac{1}{2}\mathrm{k}x^2$$ (Abdullah, 2016)

When the train moves periodically the visitor seats will experience rotation or rotational motion. Rotational motion is circular motion of an object about its rotational axis (openstax, 2016) . In rotational motion there is a concept, namely the moment of inertia. The moment of inertia shows the inertia of an object to continue rotating on its axis. It is known that the train has a shape resembling a solid cylinder so to determine the moment of inertia that works is by the equation

$$I = \frac{1}{2}\,mr^2$$

Where I is the moment of inertia (kgm ^{2}), m is the mass , (kg), and r is the radius (m). In its application, the train will not rotate without any effort given to the train. The amount of effort given can be determined by calculating the change in kinetic energy, written mathematically as follows

$$W = \frac{1}{2}\,I\omega_2^2 - \frac{1}{2}\,I\omega_1^2$$

W denotes the amount of work (Ns), I is the moment of inertia (kgm ^{2}), and ω is the angular velocity (rad/s). From the work equation on the dynamics of rotation, it can also be obtained the energy per time or power. Power can be determined by deriving the following energy equation

$$W = \tau\Delta\theta$$
$$\frac{W}{\Delta t} = \tau\frac{\Delta\theta}{\Delta t}$$

Obtained power:

$$P = \tau\omega$$

With $\tau$is the torque (Nm) and $\omega$is the angular velocity (rad/s).

Crazy Bike

Visitors the sensation of swinging and even rotating 3600. It is called a crazy bike because the passenger compartment is designed to resemble a bicycle. In this game there is an iron support that is used to support movement when swinging. This game uses an arm that connects the center

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of rotation to the visitor's seat. It is this center of rotation that plays a role in the movement of the crazy bike by utilizing engine power.



Figure 3. Crazy bike game adrenaline (source: malang-guidance)

The physics concept that occurs in crazy bike games is the concept of a mathematical pendulum and circular motion. A mathematical pendulum is shown in a swinging movement to the right and to the left resembling a pendulum swing . The circular motion shown in the swinging motion allows for a 360 ˚movement .

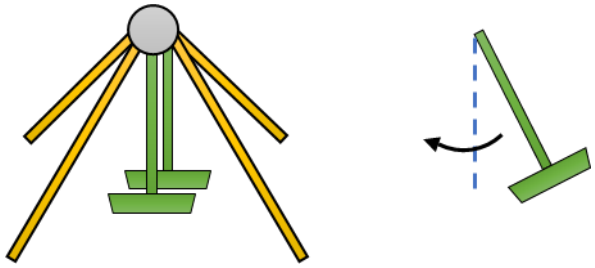


Figure 4. Illustration of crazy bike game movement

Ignoring the mass of the connecting arm of the bicycle with the rotation, the motion of the crazy bicycle swing includes a simple mathematical pendulum. In a simple mathematical pendulum, the object force is directly proportional to the displacement, provided that the deviation is not too large, that is, the angle is less than 15o (Openstax, 2016). The restoring force is expressed by the equation F= -W sinθ. Because the deviation is small, it can be written sinθ≈ θ. The angle θ is expressed in radians. So that for small deviations the restoring force can be expressed in the equation

$$F = -W\theta = -mg\theta$$

With $\theta = \frac{s}{L}$, so

$$F = -\frac{mg}{L}s$$ (Openstax, 2016)

The negative sign indicates the opposite direction to the deviation
The above equation is of the form

$$F = -kx$$

So that the force constant is obtained k = mg/L and x = s. A simple pendulum is a simple harmonic oscillator. Thus the frequency and period values of a simple mathematical pendulum can be obtained:

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

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} => \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$ (Openstax, 2016)

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When the crazy bike oscillates there is of course energy produced. The energy stored in the harmonic oscillator is in the form of potential energy EP = ½ kx ². The law of conservation of energy that applies is

$$EK + EP = Konstan$$

$$\frac{1}{2}\, mv^2 + \frac{1}{2}\mathrm{k}x^2 = konstan$$

In a simple pendulum, the values of v = ωL, k = mg/L, and x =L $\theta$are obtained

$\frac{1}{2}\, m\omega^2\mathrm{L}^2 + \frac{1}{2}\mathrm{mgL}\theta^2 = konstan$ (Opentsax, 2016)

In certain circumstances, the swinging motion of a crazy bike can exceed an angle of 15o , even the movement can reach 360o, like a circular motion. Circular motion is motion whose trajectory is circular. When the crazy bike rotates its speed is constant, but its direction changes regularly.

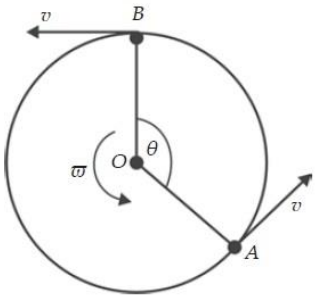


Figure 5. Circular motion *(source: Opentsax, 2016)*

When moving in a circle, the change in direction of velocity causes the direction of acceleration to always be towards the center of the circle. This acceleration is called centripetal acceleration (as).

$$a_s = \frac{v^2}{R}$$

With v = ωR it can be written as

$$a_s = \omega^2\ R$$

Drop N'Twist



Figure 6. The Drop N'Twist game stimulates adrenaline *(source: bns/attractions)*

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Drop N'Twist game is a game that originated in the United States. Drop N'Twist has two towers with a height of 56 meters. Drop N'Twist stimulates visitors' adrenaline and feels the sensation of flying up and down with a very smooth pneumatic movement and then being dropped at high speed.



Figure 7. Illustration of the state of visitors at Drop N'Twist *(source: Yusuf & Indratno, 2017).*

In a free fall game in Dunia Fantasi which is similar to the Drop N'Twist ride on BNS. When the game rides in free fall , objects around us, such as the chairs we sit on and the floor we step on, move downward because they are attracted by gravity. As illustrated in the image above, we will feel like we are floating and have no style. This doesn't mean that gravity disappears when we freely fall down, but that we just don't feel the pull of gravity.

In the game, people and all kinds of objects move in the same direction and at the same speed so that the force of gravity cannot be felt. This adrenaline game is included in physics, namely free fall motion and vertical upward motion, where "Free fall motion is defined as a motion that has no initial velocity when it is at the top point and has maximum speed at the lowest point".

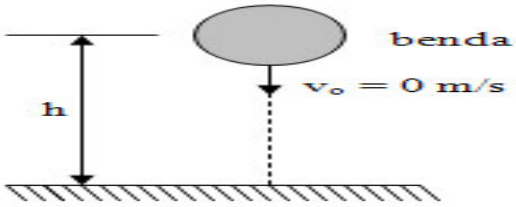


Figure 8. Free fall motion *(source: (openstax, 2016*

$v_t = v_o + gt$, the (+) sign indicates acceleration

since , the initial speed = 0, then we can write the speed as$v_t = gt$

$h = v_o t + \frac{1}{2} g t^2$, the (+) sign indicates acceleration

since , the initial speed = 0, then we can write the speed as$h = \frac{1}{2} g t^2$

${v_t}^2 = {v_o}^2 + 2gh$, the (+) sign indicates acceleration

Since the initial velocity = 0, we can write it as

$v_t = \sqrt{2gh}$

"Upward vertical motion is motion that has no velocity (v = 0) at the apex and has a maximum velocity at the starting point"

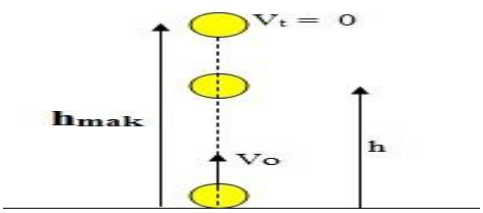


Figure 9. Vertical upward movement *(source: (openstax, 2016)*

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$v_t = v_o - gt$, the sign (-) indicates acceleration
since , the initial speed = 0, then we can write the speed as $v_t = gt$
$h = v_o t - \frac{1}{2} gt^2$, the sign (-) indicates acceleration
since , the initial speed = 0, then we can write the speed as $h = \frac{1}{2} gt^2$
${v_t}^2 = {v_o}^2 - 2gh$, the sign (-) indicates acceleration
since , the initial velocity = 0, then we can write the height, as

$$v_t = \sqrt{2gh}$$

Gravitron



Figure 10. The Gravitron game triggers adrenaline *(source: jawatimurpark.group)*

Gravitron is an adrenaline game that is well known in many countries, including Indonesia. This game has a place that resembles a flying saucer like in alien movies. Initially, visitors will stand on the gravitron wall, when the game starts the flying saucer will rotate very quickly. At the time of turning visitors will feel pushed back.

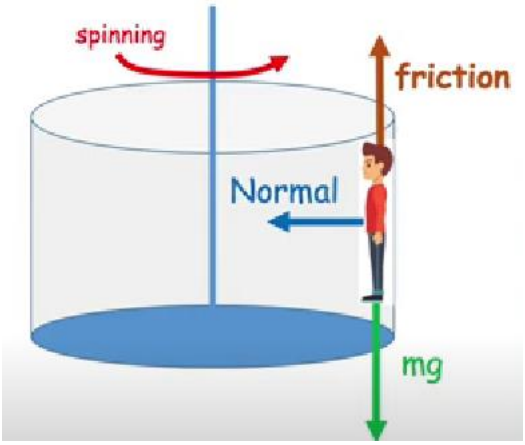


Figure 11. Illustration of the force on the game gravitron *(source : youtube.com/PhysicsNinja)*

Based on the literature study that has been carried out, it is stated that in the gravitron game there are three forces involved, namely gravity, frictional force, and normal force. Gravity (W) is related to the gravitational force on objects with mass m (W = mg). Gravity is always directed downward towards the center of the earth.

With the existence of gravity will make visitors pushed down. Therefore, in order for visitors to remain in their initial state when the gravitron rotates, there must be a force that opposes

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gravity, namely by static friction. Static friction occurs when the gravitron rotates and contacts the wall and the visitor. The direction of the frictional force is upward (opposite to gravity).

The normal force is the force that plays the most role in the gravitron game. When the gravitron rotates the tip will be pushed backwards towards the wall. However, the normal force will keep the visitor moving in a circle. On the gravitron, the normal force is always directed towards the center and is related to the centripetal acceleration. Centripetal acceleration is shown by the equation $a_s = \frac{v^2}{R}$.

The state of balance when the gravitron rotates in order to affect visitors so they can be in their equilibrium position. Based on one of the Youtube channels that we have analyzed, it explains that according to Newton's second law, there are two types of forces that occur, namely radial forces and vertical forces. The radial force is indicated by the normal force , while the vertical force is indicated by the gravity and frictional forces.

Radial style

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

Vertical Style

$$\sum F_y = 0$$
$$fs - W = 0$$
$$fs = W \text{(In a stable state)}$$

Maximum static friction conditions$fs = \mu s\ N$

$$N = \frac{\text{fs max}}{\mu s}$$

Obtained equation

$$\frac{\text{fs}}{\mu s} = \frac{m\,v^2}{R}$$
$$\frac{\text{mg}}{\mu s} = \frac{m\,v^2}{R}$$
$$v = \sqrt{\frac{gR}{\mu s}}$$

So, from the above equation to reduce the speed is to increase the value of μs. Markμs depending on the type of material used as a friction intermediary.

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CONCLUSION

In the research we did at the Batu Night Spectacular (BNS) Batu attraction, Malang, we examined the relationship between physics and adrenaline games on the rides. The adrenaline games located at the Batu Night Spectacular (BNS) playground such as Mega Disco, Crazy Bike, Drop N'Twist, and Gravitron games apply physics concepts. **1)** In the game Mega Disco there is a physics concept of oscillatory motion and rotational motion. Rotational motion is shown by repeated movements to the right and left, while rotational motion is shown in the rotation experienced by visitors' seats. The slight difference between the mega disco game and the kora kora game is that in the kora - kora game there is a connection with the center of rotation, while in the game mega disco there is no center of rotation. The magic disco game moves/oscillates using a machine, so that the movement is controlled by the machine and the paths are limited according to what has been made. **2)** In the Crazy Bike game there is a simple pendulum physics concept and circular motion. A simple pendulum is shown in a swinging motion with a connecting arm, while circular motion is shown in a crazy bicycle swinging 360 º . **3)** In the Drop N'Twist game there is a concept of vertical upward motion and free fall motion. Vertical upward motion is shown when the vehicle moves upward with initial speed and when it reaches the top point (v = 0) the vehicle will be dropped downwards with a certain speed. **4)** In the game Gravitron there are three forces that occur namely gravity, frictional force, and normal force. Gravity is influenced by gravity on a band, frictional force opposes the motion of gravity so that visitors do not fall down, and normal motion leads to the center to maintain the visitor's position when the gravitron rotates. The magnitude of the velocity that occurs can be determined by the equation $v = \sqrt{(gR/(\mu s))}$, so if you want to reduce the speed of the gravitron, increase the value of μs. The value of μs is influenced by the type of material used as a friction medium.

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Author(s):

Mohammad Bakhit Mufti (Corresponding Author)
Universitas Negeri Surabaya
E-mail: mohammad.20071@mhs.unesa.ac.id

Lely Mutakinati
Sizuoka University
E-mail: lelymutakinati@gmail.com

Nadia Dewi Masithoh
Universitas Negeri Surabaya
Email: nadia.20075@mhs.unesa.ac.id