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Analysis of Physics Concepts on Game Rides at Atlantis Island Surabaya

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ABSTRAK

Physics learning that seems boring makes physics lessons more fun if packaged in the form of games and combined with physics concepts. The purpose of this research is to find out the rides on Atlantis Island Surabaya that use the application of physics concepts. This research used a descriptive method with descriptive analysis. Data was collected by making direct observations or observations on the rides at Atlantis Island Surabaya and linking them to physics concepts. The results showed that several rides at Atlantis Island Surabaya use physics concepts in their performance, including power surge, dark coaster, wave swinger, globe of death, viking, and spilled bucket. The rides use physics concepts such as circular motion, rotational motion, kinematic motion, parabolic motion, action-reaction, centrifugal force, centripetal force, potential energy, kinetic energy, and discharge.

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INTRODUCTION

The learning process is an invisible mental activity, meaning that changes that occur in a person, both teachers and students who are learning, cannot be seen clearly, but changes that occur in the behavior of each individual can be seen. Learning has more meaning when the subject matter is presented naturally, which means it is connected to real-life situations and motivates students to make connections between the insights they gain and their application in everyday life (Pratama et., 2019). One of them is science learning, especially physics. Physics is a science that we can easily encounter in life (Anissofira et., 2016). Learning physics is more often in the classroom and focuses more on mathematical equations. Physical quantities are interrelated with everyday life (Anissofira et., 2016). Some schools have adequate facilities such as laboratories that are not often used in learning. As a result, physics loses its appeal and is of less interest to students.

Not only do facilities affect student learning, but learning resources also have a significant impact on student learning. In the 21st century, the learning process must evolve. To find new innovative things, there must be an interaction between teachers, students, and learning resources. This development can be continued for example by learning to innovate in nature as a form of variation in learning while having fun (Ismail & Raidi, 2014).

An innovative learning resource can be a tourist attraction, where students are challenged to be able to analyze and understand the application of physics concepts in everyday life. An innovative learning resource that utilizes a tourist attraction is commonly called an educational park (edupark). An educational park is a natural or artificial destination, where the learning process can be carried out. According to Rifai et al (2019), educational parks have learning support facilities that can help educators and students to find information or facts, and formulate principles or concepts in physics learning. In physics learning, active student participation is needed in making predictions, testing the concepts they believe in, and comparing them with the results of experiments they have conducted (Berkman & White, 2016).

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The utilization of tourist attractions as an innovative learning resource in physics learning will be able to change the mindset of students who tend to think that physics subjects are very difficult, boring, and monotonous because they are only focused on formulas in a fun context (Rifai et al, 2019). Amusement parks or tourist attractions can be said to be giant physics laboratories because students can practice various physics experiments that are impossible when done in the classroom. As an example of the application of physics concepts in tourist attractions or amusement parks, namely on game rides.

Various tourist attractions in a city provide various types of rides that allow us to analyze physics concepts (Yusuf & Indratno, 2017). The city of Surabaya also has a tourist attraction that offers various game rides, namely Atlantis Island Surabaya. At Atlantis Island Surabaya tourist attraction has several rides that apply the concept of physics to its performance.

RESERCH METHOD

The method used in this research is observation and descriptive method with descriptive analysis. Data collection is done through observation or direct observation of the game rides at Atlantis Island Surabaya and linking to physics concepts. This research data is primary data collected directly through direct observation.

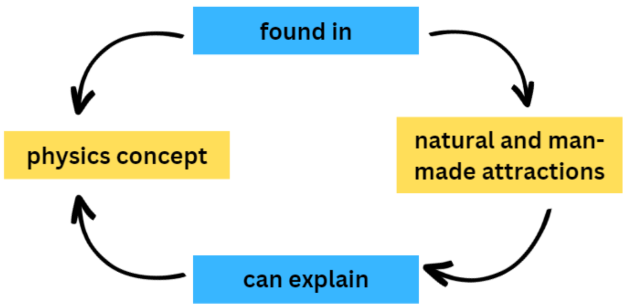

Figure 1. Chart of tourist attraction linkages with physics concepts (Rifai et al., 2014).

Pada Figure 1 shows that there is a connection between natural and artificial tourist attractions and physics concepts (Rifai et al, 2014). At Atlantis Island Surabaya tourist attraction has a lot of ride designs, such as Globe of Death, Wave Swinger, Power Surge, Viking, Dark Coaster, and Spilled Bucket. Game rides with various designs and user rules can be explained in physics concepts. This can make game rides at the Atlantis Island Surabaya tourist attraction a facility in physics learning for educators and students to explain the concepts of physics in motion.

RESULTS AND DISCUSSION

RESULTS

Utilization of Atlantis Island Surabaya tourist attraction as a learning resource by analyzing the game rides at Atlantis Island Surabaya on physics materials. The analysis of the game rides at Atlantis Island Surabaya was carried out to find physics concepts related to the work of the rides.

The results and discussion of the game rides on Atlantis Island Surabaya that have been observed have several physics concepts in them listed in Table 1.

Table 1. Analysis of the physics concept of the rides at Atlantis Island Surabaya

Number	Vehicle Name	Physics Concept
1	Power surge	Circular motion and rotational motion
2	Dark coster	Centripetal force, kinetic energy, and potential energy
3	Wave swinger	Circular motion, action – reaction, centripetal force and centrifugal force
4	Globe of Death	Circular motion and centripetal force
5	Viking	Simple harmonic motion

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Number	Vehicle Name	Physics Concept
6	Ember tumpah (swimming pool)	Discharge, potential energy, and kinetic energy

DISCUSSION

Power Surge

Power Surge rides are rides with a giant pinwheel design that rotates up and down. The work of this ride is that it can bring people who go up to feel the height then at a certain time can go down again and go up again, and so on. The Power Surge ride or what is commonly called Ferris wheel uses the concept of rotational motion and circular motion. When riding Power Surge, the working force is a combination of gravitational force and centripetal acceleration generated by rotation and angular acceleration.

Figures 2 Power surge vehicle (1)

Figure 3. Power surge vehicle (2)

The motion of the power surge vehicle is very identical to circular motion, so it can be analyzed using the equation of circular motion. Specific angular velocity using the equation:

$$\omega = \frac{2\pi}{T} = 2\pi f$$ (Löfstrand & Pendrill, 2016)

Meanwhile, to find the linear velocity value

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

Or

$$v = r\omega$$

And for the acceleration value

$$a = \omega^2 r = \frac{v^2}{r}$$ (Monteiro et al, 2014)

Dark Coaster

Dark Coaster is a ride similar to Roller Coaster rides in other theme parks. Dark Coaster rides use the physics concepts of centripetal force, potential energy, kinetic energy, and conservation of energy. Centripetal force is the force of attraction of objects whose direction accelerates to the center point (axis). The centripetal force will keep the dark coaster moving when dark coaster moves on a circular trajectory.

The motion of Dark Coaster rides can also be analyzed using the concept of potential energy. When at the top of the track, the potential energy is at its maximum value, but when at the lowest position of the track, the potential energy value is zero. As the Dark Coaster moves downhill, the potential energy turns into kinetic energy. Kinetic energy is always possessed by objects in motion.

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Figure 4. Dark Coaster ride.
Source: author document

$$Ep = mgh$$

As the Dark Coaster moves downhill the kinetic energy is at its maximum value, as kinetic energy is derived from the motion of the object, particle, or set of particles.

$$Ek = \frac{1}{2}mv^2$$ (Ristiani et al., 2018)

Wave swinger

On the Wave Swinger ride, the centripetal force obtained by each person sitting on the seat will be different from one another. A larger force will be felt by someone sitting on the end seat when compared to someone sitting near the center of the Wave Swinger. On the Wave Swinger ride, there is a centripetal acceleration perpendicular to its motion towards the center forming a centrifugal force with a direction away from the center of the circle. Centrifugal force is the force of an object moving on a circular trajectory whose direction is away from the center of the circle or rotation, while the centripetal force is generated in its direction into the center of rotation. The work of the Wave Swinger ride makes the chairs that move in a circle gradually move outward. This makes the working principle of the Wave Swinger ride by the concept of Newton's Law I, where a person will maintain his initial position when riding this ride. So that a person will get a force that is directed into the center of the circle, and the person will automatically maintain his initial position and feel the outward force.

Figure 5. Wave Swinger ride
Source: author document

The centripetal force on the Wave Swinger ride can be analyzed as shown in Figure 6.

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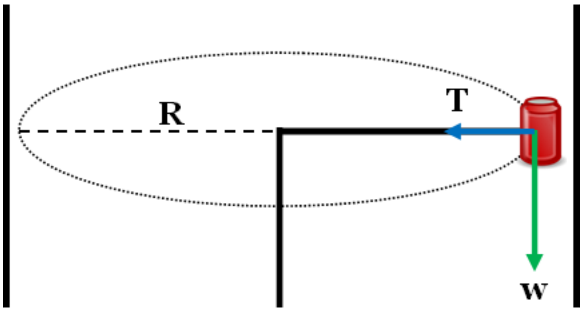

Figure 6. Illustration of a horizontally rotating Wave Swinger ride.

Based on the illustration in Figure 6, it can be seen that the Wave Swinger ride works with the downward direction of the weight force (W) and the rope tension (T) working horizontally. The tensile force on the rope that rotates the object creates rope tension. The resulting rope tension force will provide centripetal acceleration. The amount of centripetal force for a horizontally rotating object can be determined by deriving Newton's Law II formula, namely:

$$F_s = m.a_s$$

$$F_s = m.\frac{v^2}{r}$$

While the value of centrifugal force can be formulated with:

$$F = mw^2r \qquad \text{(Kusuma, 2018)}$$

Globe of Death

Globe of Death is a ride similar to the Tong Edan ride that is usually found at night markets. The physics concepts in the Globe of Death ride are circular force and centripetal force. This centripetal force is a circular motion with the direction of acceleration towards the center. The globe of death ride is always circular and goes to the bottom as the center. In this attraction, the friction force of the circle and the weight of the driver are in opposite directions to balance each other, which is what keeps the motorcycle from falling. For this reason, the larger the diameter and radius of the circle, the greater the speed required.

Figure 7. Globe of Death ride
Source: author document

Globe of Death has the physics concept of centripetal force. In addition, the regular circular motion of the motor on the globe of death rotates on a circular track with a 90˚ tilt angle. The motor that moves on the Globe of Death ride does not fall because it is influenced by several forces that work. The forces acting on the Globe of Death ride are the downward direction of gravity and the frictional force of the track, which is opposite to the force of gravity, which is upward. Centripetal acceleration is the acceleration that occurs in regular circular motion and its direction is toward the center of the circle. When an object moves with a certain speed around a circular path, the amount of centripetal acceleration is as follows:

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

With v is the linear rate of the object with units (m/s), ω (omega) is the angular rate of the object with units (rad/s), and R is the radius of the object's trajectory with units (m).

According to the concept of Newton's Law II, objects can move because they are caused by an accelerating force. Centripetal force is the resultant force of the force acting on the object in the radial direction (Adetyas Ristiani, 2018). This force is what causes centripetal acceleration. The amount of centripetal force is obtained by the equation:

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

Viking

The Viking Ride applies several physics concepts. The Viking ride moves in a semicircle by going back and forth like a pendulum, so the motion on the Viking ride contains the physics concept of simple harmonic motion (Adetyas Ristiani, 2018). According to Wahid et al (2020), simple harmonic motion is an alternating motion of objects with the number of vibrations of objects every second that is always constant at a certain equilibrium point.

Figure 8. Viking ride
Source: author document

Viking also applies several physics concepts to its movements, such as amplitude (A), vibration period (T), vibration frequency (f), angular deviation, angular velocity, phase angle (θ), vibration phase (φ), and phase difference ($\Delta\varphi$). Amplitude (A) is the farthest deviation measured from the equilibrium point of vibration. The period of vibration (T) is the amount of time required to produce one complete vibration. The Viking vehicle moving with simple harmonic motion makes it have a period with the equation:

$$T = \frac{1}{f}$$

The vibration frequency (f) is the number of vibrations that occur during one second, which is calculated by the equation

$$f = \frac{1}{T}$$

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The angular deviation is the ratio between the radius of the circle (r) and the linear distance X, and is expressed by the equation:

$$\theta = \frac{x}{\gamma} = \frac{vt}{\gamma}$$

Angular velocity is the amount of angle traveled in one second and is calculated by the following equation:

$$\omega \; = \; 2\pi f \; = \frac{2\pi}{T} rad/s$$

The phase angle (θ) is the amount of angle traveled by a point during simple harmonic motion, the amount is:

$$\theta \; = \; \omega t$$

The phase of vibration (φ) is the ratio between the phase angle (θ) and the maximum phase angle (2пf) or the ratio of the amount of time the point vibrates (t) to its period (T). The vibration phase is calculated by the following equation:

$$\varphi = \frac{t}{T} = \frac{\theta}{2\pi}$$

Phase Difference ($\Delta\varphi$) is the phase difference between the two positions of a point that is in harmonic vibration, The phase difference is calculated by the following equation:

$$\Delta\varphi = \frac{\Delta t}{T} = \frac{\Delta\theta}{2\pi}$$

Ember Tumpah
On the swimming pool ride, there is a spilling bucket. The bucket is filled with water and then when the bucket is full, the bucket will spill down (swimming pool). This spilling bucket ride uses the physics concepts of discharge, kinetic energy, and potential energy.

Figure 9. Spilled Bucket Rides in the Pool
Source: author document

The spilled bucket is filled with water flowing in 2 cross sections on the left and right sides, so there is the concept of physics of discharge in the spilled bucket. Flow discharge is the volume of flow that flows through a cross-section per second with units of m3 / s (Tombokan & Takaendengan., 2022). The flow discharge measurement is calculated using the following equation Setiawan & Purwanto (2018):

$$Q = V.A$$

With Q is the discharge with units (m^3/s), V is the flow velocity with units (m/s), and A is the size of the cross-sectional area with units (m^2). When the bucket is filled with water, there is potential energy due to the height position of the spilled bucket. Potential energy can be found by the equation:

$$Ep = mgh$$

Potential energy turns into kinetic energy when the bucket is filled with water and spills downward. When moving downward (spilling) the kinetic energy is at its maximum, as kinetic energy is derived from the motion of an object, particle, or set of particles.

$$Ek = \frac{1}{2}mv^2$$

CONCLUSION

Based on research that we have done on tourist attractions or amusement parks, namely on game rides located at one of them at Atlantis Island Surabaya. At Atlantis Island Surabaya tourist attraction has several rides that apply the concept of physics to its performance. Some of the rides include power surge, dark coster, wave swinger, globe of death, viking, and tumbling bucket (in the swimming pool). The rides have the concept of physics for their performance, students can make the rides one of the applications of the concept of physics in life, besides that game rides are not only for entertainment but also as a means to learn physics in the application of game rides.

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