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Study of Physics Learning in Indoor Games at Transmart Surabaya

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ABSTRACT

This study aims to examine the learning of physics in indoor games at Transmart Surabaya. This study uses a qualitative descriptive method, namely by using a documentation study. The target of this research is a modern game that applies the concept of physics contained in the Studio Mini Transmart Surabaya. The method of data collection carried out in this study used the observation method. In this study, it was concluded that some of the games contained in Trans Studio Mini Transmart Rungkut, Surabaya, namely roller coaster games, new york (rotating swing), sky rider, mini electric car, mini train, and bumper car applied several physics concepts. The roller coaster game applies the concept of mechanical energy. In the new york game, the physics concept is applied, namely the concept of rotational motion and harmonic motion. In the game sky rider applies the concept of physics, namely the force of gravity, rotational and circular motion and the moment of inertia. In the mini electric car game, the concept of physics is applied, namely the concept of displacement, velocity, acceleration and friction. In the mini train game, the physics concept is applied, namely acceleration and friction. As well as in the bumper car game applying the concepts of physics, namely acceleration, collision and the law of conservation of momentum.

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INTRODUCTION

Physics is a science that studies natural phenomena. In general, physics is identical with formulas that make students feel that learning physics is very difficult. However, along with technological developments, learning physics can be done through several other innovations that can make it easier for students to understand physics learning. In addition, with the latest innovations related to ways to understand physics concepts, students are able to carry out direct understanding through analysis of physics concepts in a technology-based game. That way, physics that was initially felt difficult can be understood easily when analyzing physics concepts directly in a game.

Physics of natural behavior in various forms of symptoms to be able to understand what controls or determines that behavior. Based on this, learning physics cannot be separated from mastering the basic concepts of physics through understanding (Nursanti, 2021). Physics is the basic knowledge needed for the advancement and development of technology in the future, creativity is one way to integrate it. Learning physics requires active students so that it will strengthen their understanding of physics concepts. For high school students, the concept of learning physics is more difficult when the topic is abstract (Medya, 2020).

Nowadays, the development of science, especially in the field of science, is very rapid. This is triggered by the increasing population growth in the world which causes many problems in all fields. Apart from these factors, the role of education is also very instrumental in advancing a

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human civilization. From these problems, humans are required to provide solutions to overcome them, which causes technology to develop very rapidly in the current era. One of the sciences that affect human civilization is science. Science is the systematic knowledge of nature and the physical world, including botany, physics, chemistry, geology, zoology, and so on. Physics is also one of the sciences that studies the relationship between matter and energy (Sony, 2018).

Along with the development of technology, physics can be applied to many things, one of which is in modern games. Modern games are games created by companies or industries that use advanced technology. There are so many kinds of modern games such as Arcade Games, PC Games, Console Games, Handle Games, Mobile Games and VR Games (Pretty, 2019). Modern technology-based games generally develop in urban areas where the level of economic and technological development is quite high. One of the cities that has modern technology-based games is the city of Surabaya.

Surabaya is the capital city of East Java Province which has the nickname as the City of Heroes and has a variety of tourist destinations. There are various kinds of tourist destinations that are so interesting ranging from nature tourism, water tourism, and various other tours in Surabaya, some tourist attractions in the city of Surabaya include the Heroes Monument, Atlantis Land Surabaya Tour, Surabaya Zoo, Food Junction Pakuwon, Suroboyo Carnival, Mangrove, trans studio, and so on. (Muizzatul, 2019).

Trans Studio is one of the tourist attractions in the city of Surabaya where there are modern technology-based games. Trans Studio Mini is an indoor theme park at Transmart with various kinds of rides like those in Trans Studio but in a smaller size. The existence of Trans Studio Mini is an extraordinary magnet for Transmart Rungkut Surabaya because it can meet the entertainment needs of the community in one place. The presence of Trans Studio Mini adds to the existing amusement park in the East Surabaya area with a more modern concept. (Ari, 2019). Based on this preliminary description, this study aims to examine physics learning in indoor games at Transmart Surabaya.

RESEARCH METHOD

The type of research used is descriptive qualitative research by using documentation studies. The stages of the research carried out are: (1) Determining the place to make observations related to game rides that apply the concept of physics (2) Conducting observations at the Trans Studio Mini Transmart Rungkut, Surabaya by taking documentation in the form of taking pictures of the rides in Trans Studio Mini Rungkut Transmart Surabaya. (3) Identify what physics concepts are applied to these vehicles. (4) Selecting several vehicles for which a more in-depth analysis of physics concepts will be carried out. (5) Analyze the physics concepts contained in the selected vehicle. (6) Formulate the results of the study.

The target of this research is a modern game that applies the concept of physics contained in the Studio Mini Transmart Surabaya. The method of data collection carried out in this study used the observation method. This observation method is used to obtain information about the game and which will later analyze any games that apply the concept of physics at the Trans Studio Mini Transmart Rungkut, Surabaya. In addition, there are two methods of data analysis used, namely: analysis of information related to physics concepts through literature studies, and observational analysis to study physics concepts applied to games at Trans Studio Mini Transmart Rungkut, Surabaya.

Figure 1. The procedure for the flow of research methods related to the study of physics learning in indoor games at Transmart Surabaya.

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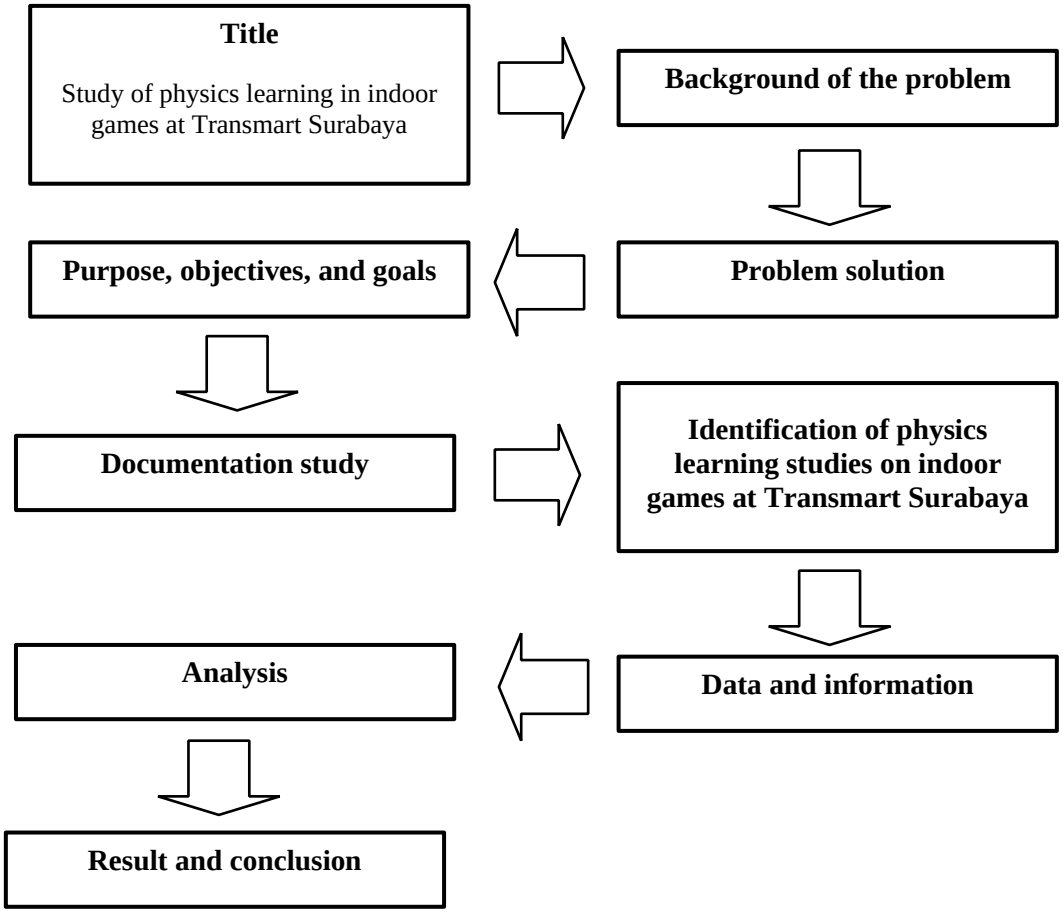

Figure 1. Research flowchart

RESULTS A ND DISCUSSION

Based on the results of observations and literature studies at Transmart Studio Mini Rungkut, Surabaya, there are several rides that apply several physics concepts, including:

1. **Roller Coaster**

Figure 2. Roller coaster game

Roller coaster is a game that applies the physics concept of object acceleration in terms of its mechanical energy. Mechanical energy is the total energy carried out by a system whether the system is at rest or in a state of motion.

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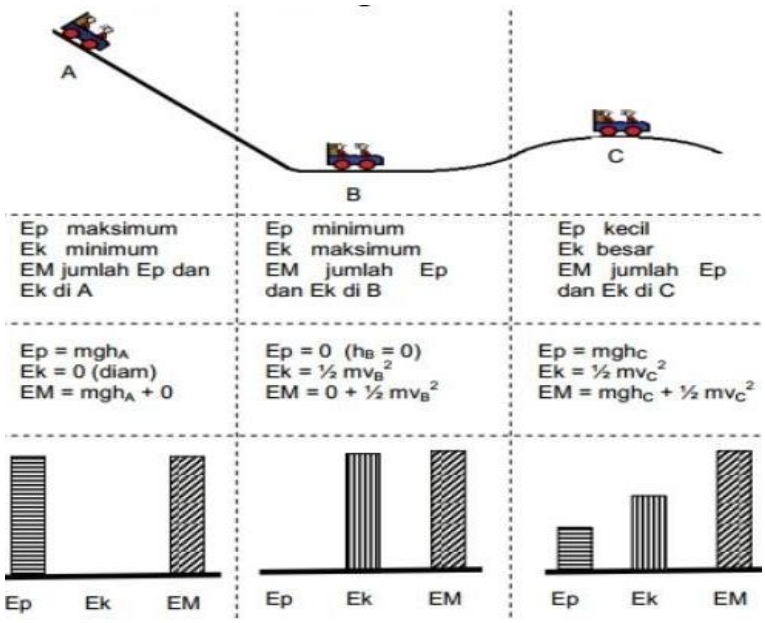

Figure 3. Graph of energy transfer on a roller coaster
(Source: https://journal.fisika.or.id/)

Figure 3 shows a graph of energy transfer on a roller coaster. Based on the theory of work and energy, the mechanical energy of a roller coaster is not only affected by the position or state of the track but also by friction. If W is the compressive force of an object on a path with a coefficient of friction, then the magnitude of the frictional force

$$Fges = W \ldots\ldots\ldots (1)$$

If there is relative motion between two surfaces, the frictional force is called kinetic friction. Kinetic friction has a direction opposite to the direction of the object's motion which causes the object to slow down. However, students often experience misconceptions in analyzing roller coaster movements.

Based on the schematic of the tool in Figure 3, it is known that the value of the mechanical energy at position A is the same as the mechanical energy at position B

$$EMA = EMB \ldots\ldots\ldots (2)$$

while the kinetic energy at A is zero and the value of potential energy at B is also zero so that the value of potential energy at A is the same as the kinetic energy at B

$$EpA = EkB \ldots\ldots\ldots (3)$$

with $Ek = 1/2mv^2$(2). Furthermore, by analyzing the movement of objects on a trajectory using Uniformly Changing Motion (GLBB) it is obtained.

$$v = v0 + at \ldots\ldots (4)$$

Since the object is not given an initial velocity then v0 is zero. Then substituting equation (4) into equation (3) produces equation

$$a^2 = \frac{2Ek}{mt^2} \ldots\ldots (5)$$

where m is the mass in kilograms and t is the time taken by the lego car in seconds

2. New York (Swing Spin)

Figure 4. New York game (swing spin)

New York is also known for its giant spinning swing game. This new york game is often found in various playgrounds. The principle of this game is almost the same as the carousel game. In this New York game, some physics concepts are applied. In this game there are physics concepts, namely rotational motion and simple harmonic motion on the pendulum and there is energy in the harmonic motion.

Rotational motion is the motion of an object or construction component with a circular path to a central point. The component of the construction is a rigid body that rotates about a fixed axis, so the distance of each particle in the system to the axis of rotation will always remain constant. (Pangalinan, 2018).

Simple harmonic motion on a pendulum, namely the swing of a pendulum (pendulum) is one of the phenomena in physics lessons that shows oscillatory motion (Suwarno, 2015). Oscillation can be defined as the back and forth motion of an object that occurs periodically or periodically, that is, the motion of the object repeats itself at a fixed time interval (Paramita, 2015). An important characteristic of oscillatory motion is the frequency or number of oscillations completed per second. The quantity related to frequency is the period of motion, i.e. the time it takes to complete one oscillation (or cycle) (Halliday et al, 2015).

$$T = \frac{1}{f} \ldots\ldots (6)$$

$$f = \frac{1}{T} \ldots\ldots (7)$$

In the book Physics for Science and Engineering Volume 1 states that the motion of a pendulum is simple harmonic motion only if the amplitude of the vibration is small. Figure 5 shows a simple pendulum consisting of a string of length L and a weight of mass m (Tipler, 1991).

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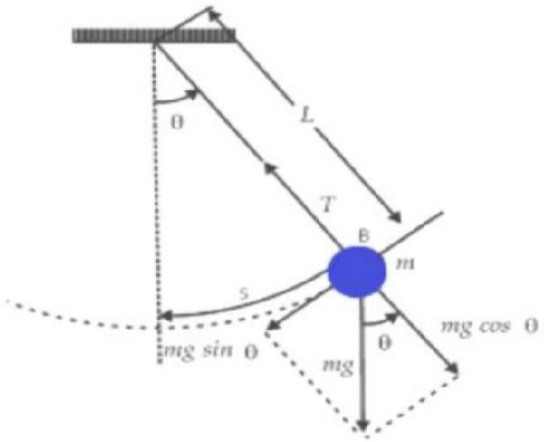

Figure 5. Pendulum motion oscillation

(Tipler, 1991)

The force acting on the load is its weight mg and the tension T on the rope. When the rope makes an angle with the vertical, the weight has components mgcos along the rope and mgsin perpendicular to the rope in the direction of decreasing. Let s be the length of the arc measured from the base of the circle. The arc length is connected to the angle by

$$s = L\theta \ldots\ldots. (8)$$

Simple harmonic motion can be studied more fully with energy considerations. The Law of Conservation of Mechanical Energy states that: "In harmonic vibrations there is an exchange of potential energy into kinetic energy or vice versa, but the mechanical energy, namely the total potential energy and kinetic energy remains" (Young, 2002). Kinetic energy is the energy contained in any object that is moving.

$$Ek = 1/2\, mv^2 \ldots\ldots. (9)$$

Meanwhile, potential energy is the energy possessed by an object because of its position or condition which indicates that work or work can be done. Mathematically, the gravitational potential energy is as follows:

$$Ep = mgh \ldots\ldots. (10)$$

Mechanical energy is the sum of kinetic energy and potential energy

$$Em = Ep + Ek \ldots\ldots. (11)$$

3. Sky Rider

Figure 6. Sky rider

Sky Rider is a type of game that is similar to a merry-go-round but takes the form of a plane and there are times when the air springs seem to be lifted. This game applies the

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concepts of physics, namely the force of gravity, rotational and circular motion and the moment of inertia.

The gravitational force is the attraction caused by objects that have mass (eg Earth). The magnitude of the gravitational force depends on the location of the object or the height of the object from the planet that causes the gravitational force. The magnitude of the gravitational force depends on the location of the object or the height of the object from the planet that causes the gravitational force. For example, the weight of an object on earth is equal to the magnitude of the earth's gravitational force on the object. The weight of the object on the moon is equal to the magnitude of the moon's gravitational force on the object (Ernawati, 2021). When the sky rider game is in a state of rest/stillness, there is a gravitational force to keep it rotating on its axis.

Rotational motion is the motion of an object or construction component with a circular path to a central point. The component of the construction is a rigid body that rotates about a fixed axis, so the distance of each particle in the system to the axis of rotation will always remain constant. (Pangalinan, 2018).

Circular motion or also called circular motion is the movement of an object that forms a circular path with one axis or fixed point in the middle. A movement can rotate, because there is a force that can turn it towards the center or axis of the circle's trajectory, this force is called centripetal force (Fs) (Irnin, 2021). The circular motion that applies to the sky rider game is Circular Motion Changing Regularly (GMBB), because the rotation in the sky rider game gradually gets quieter or stops with the engine.

Some of the physical quantities of uniform circular motion in the sky rider game include:

1) Angle size

In Figure 6, the sky rider game moves around a circle with radius r so that it has a circular path. In general, the angle measure is written as follows:

$$\theta = \frac{s}{r} \ldots\ldots\ldots (12)$$

where, is the angle measure (rad), s is the arc length (m), and r is the radius of the circle (m)

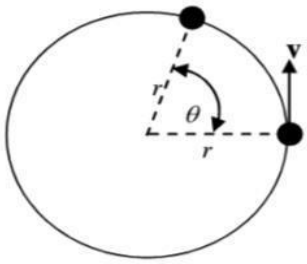

Figure 7. The particle moves a distance s in a circular path of radius r, with an angle of position (Vogt and J. Kuhn, 2013)

In circular motion, the quantity expressed how far the object moves (θ) in an interval of time (t) is called the angular velocity or angular velocity.

$$\omega = \lim_{\triangle t \to 0} \frac{\triangle \theta}{\triangle t} = \frac{d\theta}{dt} \ldots\ldots\ldots (13)$$

The unit for angular velocity is rad/s, in addition to that unit it can also be written rpm (rotation per minute), 1 rpm = 2π radians/minute = /30 rad/s (Halliday, et al. 2010).

2) Period and frequency

The period is the time it takes for the sky rider game to complete one full round. The period of circular motion can be expressed by the following equation:

$$n = n/\ N \ldots\ldots\ldots (14)$$

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While the frequency is the number of rounds in the sky rider game in one second. So the frequency of circular motion can be expressed by the following equation:

$$t = nf \ldots\ldots\ldots (15)$$

The relationship between period (T) and frequency (f) can be expressed by equations (1) and (2). While the relationship between angular velocity with period and frequency can be expressed by the following equation:

$$\omega = 2\pi/T \ldots\ldots (16)$$

$$\omega = 2\pi f \ldots\ldots\ldots (17)$$

3) The relationship between angular velocity and linear speed.

The relationship between angular velocity and linear velocity can be expressed by the following equation:

$$v = \omega r \ldots\ldots (18)$$

based on press 16, then:

$$v = \frac{2\pi r}{T} \ldots\ldots (19)$$

Angular acceleration, linear acceleration, and centripetal acceleration In circular motion, there are three magnitudes of acceleration, namely angular acceleration (α), linear acceleration (a), and centripetal acceleration (as). The angular acceleration (α) is defined as the change in angular velocity (ω) in the time interval t and is mathematically expressed by the following equation:

$$\alpha = \frac{\Delta\omega}{\Delta t} \ldots\ldots (20)$$

where is the angular acceleration (rad/ s^2).

Linear velocity during its motion, the particle has a linear acceleration which can be mathematically expressed by the following equation:

$$a = r\frac{\Delta\omega}{\Delta t} = r\alpha \ldots\ldots\ldots (21)$$

where a is the linear acceleration (m/ s^2).

Centripetal acceleration is the acceleration of an object whose direction is towards the center of the circle can be determined by the following equation:

$$as = \frac{v^2}{r} = \omega^2 r \ldots\ldots (22)$$

Moment of inertia Moment of inertia is the tendency of an object to maintain a state of rotational motion. The farther the position of the mass of the object to the center of rotation, the greater the moment of inertia of the object (Irnin, 2021). The moment of inertia in the Sky Rider game occurs when the game maintains its rotating state .

4. Mini Electric Car

Figure 8. Mini electric car

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Mini Electric Car is an electric toy car game. The principle of this game uses the principle of an electric car. In this game apply the concepts of physics, namely displacement, velocity, acceleration and friction

When the mini electric car game is played, there will be a displacement from its original position. Position is the position of an object from a certain reference. Displacement is a change in position in a certain time interval. Displacement is a vector quantity. If you want to move from the initial position 1 to the final position 2 then the displacement is

= 2 1 ……. (23)

Displacement does not depend on the path traveled by the object. Displacement only depends on the initial position ($x1$) and the final position of the object ($x2$) (Sri ,2017).

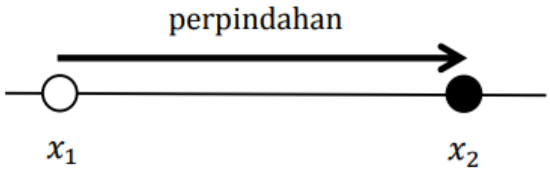

Figure 9. Schematic of displacement

Distance is the length of the path traveled by an object in a certain time interval. Distance is a scalar quantity. (Nuryanti, Ade Yeti and Septia Mahen, Ea Cahya. 2017 :30-31).

When the mini electric car game is played and there is a displacement at a certain time, the game applies the concept of physics, namely the average speed and instantaneous speed. If the particle has moved a distance and takes time for the displacement, then the average velocity is the ratio between the displacement and the time interval of the displacement (Sri, 2017).

The concept of instantaneous speed physics in this mini electric car game occurs when the game moves at a certain speed at a certain time which has a time interval close to zero. Instantaneous speed is the speed at a certain time or the average speed whose time interval is close to zero (Sri, 2017).

= lim →0 = ……. (24)

Thus, the average speed in the mini electric car game does not depend on the trajectory but depends on the initial position ($x1$) and the final position ($x2$). The direction of the instantaneous velocity is along the line tangent to the object's trajectory curve.

In the mini electric car game, displacement occurs and has a speed so that in this game it has both an average acceleration and an instantaneous acceleration. The average acceleration in this game occurs when the mini electric car moves in a straight line by having a change in speed at a certain time interval. Average acceleration is the change in velocity over a certain period of time.

= ……. (25)

= average acceleration (m/s2)
= change in object's velocity (m/s)
= the time it takes the object to move (s)

(Sri ,2017)

While the instantaneous acceleration occurs when the mini electric car moves in a straight line with a speed so that it has an average acceleration with an interval of time to zero. Instantaneous acceleration is the average acceleration over time to zero. The magnitude of the instantaneous acceleration is:

= lim →0 = ……. (26)

(Sri ,2017)

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Friction forces include the touch force, which arises when the surfaces of two objects are in direct physical contact, this force has a direction opposite to the direction of motion of the object and in the same direction as the surface of the touch plane. In general, the frictional force of an object can be classified into two types, namely static friction (fs) and kinetic friction (fk). Static friction is the frictional force acting on an object at rest, while kinetic friction is the frictional force acting on an object in motion. (Sham,2019)

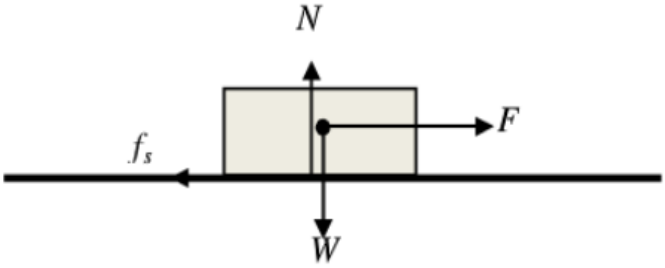

Figure 10. Objects on the surface form a frictional force

The frictional force generated in the mini electric car game has three characteristics, namely:

1) If the value of F<fs, then the mini electric car is at rest, then fs and the component of F parallel to the surface have the same value, and fs is in the opposite direction to the component of F.
2) If the value of F = fs, then the mini electric car game is right when it is about to move
3) If the value of F> fs, then the mini electric car game moves and the static friction force fs will turn into a kinetic friction force

5. Mini Train

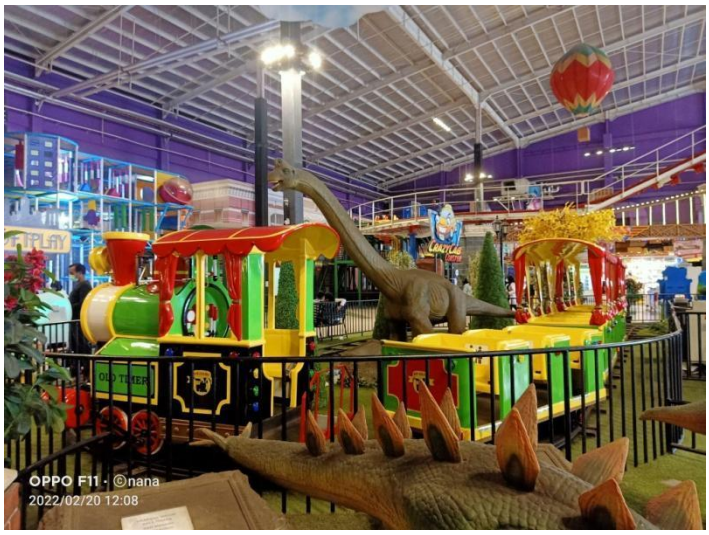

Figure 11. Mini train

Mini Train is a mini train game that runs on a track. This game applies the concepts of physics, namely long expansion, acceleration and friction. This mini train when running will experience acceleration due to displacement and speed. In this mini train game there is friction between the train wheels and the track so that there is a frictional force that occurs in this mini train game.

On the track of this mini train game there is the concept of expansion, where the making of the track in this game is given a gap in the track or what is called a rail that applies the concept of physics, namely long expansion. Expansion is the process of

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increasing the volume of a substance due to an increase in temperature or absorption of heat. This material is chosen because many of the expansion materials are real in everyday life. For example, giving a gap on a railroad track as an example of long expansion, giving a gap in the installation of a window as an example of wide expansion, and matches that explode when heated as an example of volume expansion, making it easier for students to master material concepts that arise in the learning process. (Eva, 2021)

Friction forces include the touch force, which arises when the surfaces of two objects are in direct physical contact, this force has a direction opposite to the direction of motion of the object and in the same direction as the surface of the touch plane. In general, the frictional force of an object can be classified into two types, namely static friction (fs) and kinetic friction (fk). Static friction is a frictional force that acts on an object at rest, while kinetic friction is a frictional force that acts on an object in motion (Syam, 2019).

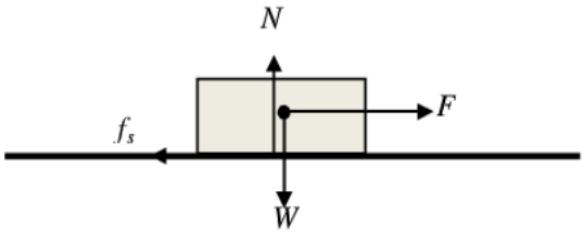

Figure 12. Objects on the surface form a frictional force

The friction force generated in the mini train game has three characteristics, namely:

1. If the value of F<fs, then the mini train is at rest, then fs and the component of F parallel to the surface have the same value, and fs is in the opposite direction to the component of F.
2. If the value of F = fs, then the mini train game is about to move
3. If the value of F> fs, then the mini train game moves and the static friction force fs will turn into a kinetic friction force

6. Bumper Car

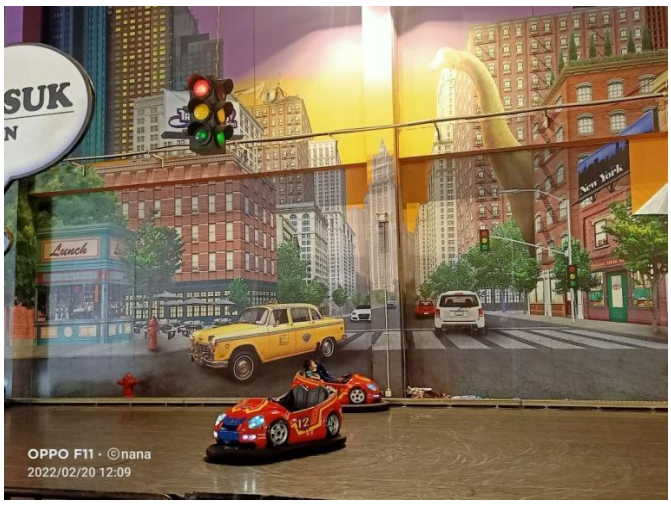

Figure 13. Bumper car

Bumper car is a small, electrically powered car game that draws power from the floor and is switched on and off remotely by the operator. In this game apply the concepts of physics, namely acceleration and collision. Where when the bumper car is moving it will have acceleration. In this game the players often collide with each other so that they apply the concept of physics, namely collisions.

Collision is one of the materials contained in physics lessons. A collision is an event where two moving objects meet. Contextual events of the collision process can be found easily in everyday life (Fani, 2018).

When entering the arena, the bomb car or the car bumped. This arena is the best arena for learning collisions. The bump car moves with electric power obtained from the electric grid above it. On the connecting rod of the car with the nets, electric sparks are often seen due to the very high voltage in this grid. Sparks are seen when the stick's connection to the net is severed. Because the energy obtained by each car is the same, light passenger cars can move relatively quickly. So that when they collide, you feel comfortable, so around the car is given a rubber belt. This rubber will absorb the impact of the collision. 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.

The law of conservation of momentum is usually used to solve the collision problem of two or more objects. The law of conservation of momentum states that : "the total momentum before the collision is always the same as the total momentum after the collision". However, the essential concept of momentum is experimentally difficult to prove in classroom learning because it is difficult to determine the right media for this process in learning (Prima et al., 2016).

There is a difference in the magnitude of the momentum before and after the collision in the Bumper car game, this happens due to several factors, one of which is the friction between the Bumper car sliding game with the air or the friction between the Bumper car sliding game and the sliding track. Similar to the experiment on the tool developed by Huda et al. (2016), there is a difference in the magnitude of the momentum before the collision and after the collision in the conditions 1 = $m2$ and 1 > 2 (different values).

When one of the first bumper car games moves so that it hits the second bumper car game that is still. So after the collision the first bumper car game which has a smaller mass bounces off and moves to the left in the direction of the second bumper car game, so that the momentum of the collision without external force is obtained. In the case of a collision without an external force, the law of conservation of momentum will always apply, namely the total momentum of the object before the collision is the same as the total momentum of the object after the collision (Rosyadi, 2018). The amount of momentum after the collision has a value that is close to the magnitude of the momentum before the collision.

CONCLUSION

In this study, it was concluded that some of the games contained in Trans Studio Mini Transmart Rungkut, Surabaya, namely roller coaster games, new york (rotating swing), sky rider, mini electric car, mini train, and bumper car applied several physics concepts. The roller coaster game applies the concept of mechanical energy. In the new york game, the physics concept is applied, namely the concept of rotational motion and harmonic motion. In the game sky rider applies the concept of physics, namely the force of gravity, rotational and circular motion and the moment of inertia. In the mini electric car game, the concept of physics is applied, namely the concept of displacement, velocity, acceleration and friction. In the mini train game, the physics concept is applied, namely acceleration and friction. As well as in the bumper car game applying the concepts of physics, namely acceleration, collision and the law of conservation of momentum.

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