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Exploring Learning Physics Concepts Through the Local Wisdom of East Kalimantan Culture: Traditional Weapons, *Sumpit*

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Abstract: Cultural diversity in Indonesia is due to the many islands that consist of various ethnicities, religions, and backgrounds. This cultural diversity can be a source of learning that can increase students' understanding and motivation to learn. One of the sciences that can be used to integrate with cultural diversity or local wisdom is physics. Physics is able to explain scientifically how a phenomenon in local culture occurs. Unfortunately, the integration of physics in local culture is still rare. Through this research, it is expected that there will be more references that discuss the integration of physics concepts in various types of local cultures. The purpose of this research is to identify and analyse physics concepts in the local culture of East Kalimantan people, especially the traditional weapon of sumpit. This research uses a qualitative descriptive research method oriented towards the exploration of physics concepts. Primary data in this study was obtained through interviews to find out how to use sumpit properly and correctly. The interviewees were selected using purposive sampling technique. Data was also collected through experiments to prove the concepts of physics contained in the traditional weapon of sumpit. Based on the results of the interview, it was found that sumpit are currently not used as weapons, but have developed into traditional games by the local community. In the traditional game of sumpit from East Kalimantan, physics concepts were analysed in the stages of using sumpit. Starting from the start of lifting the sumpit, blowing the sumpit, the movement of the damak inside the sumpit, the process of the damak coming out of the sumpit, to when the damak hits the target. From the results of the analysis, several physics concepts are obtained that occur during the process of using chopsticks, namely in the physics of mechanics, the concepts of parabolic motion, force, effort, momentum and collision, simple aircraft, and kinetic energy are used. In fluid physics, the concepts of aerodynamics and gas pressure are used. In wave physics, the concept of sound waves is used. Based on the results and discussion, it can be concluded that every movement and condition that occurs when sumpit can be studied physically. Therefore, the exploration of physics concepts in local wisdom needs to be improved to increase the reference of teaching materials on physics material.

Keywords: sumpit, local wisdom, physics concept.

▪ INTRODUCTION

The technological revolution that runs massively and quickly has an impact on various fields including education (Pintaningdyah, Syah & Karnati, 2024). The teaching skills of the teaching profession in utilizing digital developments need to be improved (Marpanaji, Mahali, Putra, 2018). In the era of the industrial revolution 4.0 which is related to digitalization and has an impact on the education sector, especially in physics learning, there are various obstacles felt by both educators and students, including the lack of innovation related to physics. To keep up with current developments, humans are required to have a better understanding of physics (Wibowo, Azhari, & Deta, 2024). In accordance with research (Hidayatullah, Qomariyah, & Krisnahadi, 2024) stated that the

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role of the teacher is very influential in achieving goals in learning by adjusting the character of students.

But in fact, physics learning is still experiencing problems, especially reasoning and understanding related to concepts that are beyond the imagination of students (Listianingrum et al, 2024; Syamsudin, Sukarmin & Sarwanto, 2023; Rahmati, Halim, Yusrizal, 2022). Thus, students think that physics is difficult and boring because they think that in general physics learning is identical to complicated math. The material is very complicated to learn so that thinking skills are needed to develop understanding and improve cognitive performance, namely by using metacognitive skills (Jakiyah & Suratno, 2024). Based on Ministerial Regulation No. 22/2016 on process standards in learning, it is recommended to use problem-based learning to encourage students' skills. In addition, students, especially at the senior high school level, are expected to be able to integrate culture in learning (Permendikbud, 2016). This is also in accordance with research conducted (Derlina et al, 2021; Rahmawati et al, 2019) stated that improving science skills in students through Ethnophysics learning can improve students' skills.

Examining cultural elements with physics concepts can make it easier for students to understand the material and its application more deeply (Rahayu et al, 2023). In learning, students must know the relevance of learning in everyday life (Sumarni, 2017). The education advocated today is ethnoscience (Kuniawan et al, 2020) The word ethnoscience comes from the word ethnos which means nation and Scientia which means knowledge (George, 1991; Moriolkosu, Handayani, & Sunarno, 2020; Prahani & Cheng, 2021). In other words, ethnoscience is a branch of science that studies the characteristics and lives of the indigenous people of a society. Often closely related to the philosophy and ideology of life that is very influential in survival (Suprapto & Utama, 2021). Ethnoscience is also an activity of moving between indigenous science and scientific science. Where indigenous knowledge consists of knowledge that alludes to facts of society (Ahmadi, 2019).

So far, physics and local wisdom are considered as two different things, even though the two sciences can be integrated with each other so that it has an impact on learning that is more meaningful and gives a new impression to students (Putra, Handayani, & Prihandono, 2024). The integration of local wisdom is often associated with tribes in the interior because it has its own uniqueness to be studied (Safiti & Salma, 2023). One of them is the traditional game of sumpit (Agusti dkk., 2018; Nasution, 2019). Sumpit are a local wisdom originating from East Kalimantan (Arifin dkk., 2022). Sumpit fall into the category of traditional weapons. Sumpit have several names in East Kalimantan, such as keleput from the Dayak Kenyah, seput from the Dayak Bulungan tribe, sumpit from the Dayak Berau tribe, and seput from the Dayak Benua tribe (Dallas, 2022). The main function of sumpit is as a weapon for hunting animals (Howson, 2018; Sinaga et al., 2023). In the second world war, sumpit were used as a weapon of war against invaders, due to their advantages of being able to be used as a long-range weapon and not making a sound (Susanto et al., 2021).

In addition, sumpit are also used as a traditional game, demonstrating the power of sumpit and hitting the right target. Having the skill to use sumpit is a matter of pride for Dayak youth, sumpit are also used as a folk game. Currently, sumpit have been included in various competitions, one of which is in the field of sports championships (Astuti dkk, 2022). As in the Erau Festival, Tenggarong, a sumpit competition was held which aims

to preserve the culture of the Kutai and Dayak tribes spread throughout Kutai Kartanegara Regency. Based on the description of the problem above, the purpose of writing this article is to integrate the local culture of the people of East Kalimantan with physics learning.

▪ METHOD

The study consisted of one participant, selected based on their skills and knowledge of the traditional weapon, sumpit. Purposive sampling was used to ensure that participants had the necessary expertise to provide relevant and in-depth insight into sumpit use's cultural and physical aspects (Ames et al., 2019). The sample chosen was FDH, a native of Kalimantan and a summit expert with over 3 years of experience. FDH is also an athlete from Bontang, East Kalimantan, with 5 years of experience and participation in various traditional sports events. Additionally, experiments were conducted to validate the physics concepts found in the traditional Kalimantan *sumpit.*

Figure 1. One of the achievements of a national level speaker

This research uses a qualitative research design to explore the integration of local wisdom in physics learning. The procedure includes a literature review study to find out an initial picture. Next, initial familiarization with participants, detailed observations of participants demonstrating the usefulness of sumpit, and structured interviews were conducted to collect comprehensive data regarding the physical principles and cultural significance of *sumpitan*.

Primary data was obtained through interviews with a focus on four main things: *sumpit* users (9 questions), tools (4 questions), uses (5 questions), and other factors (4 questions). Observations are used as secondary data to support the exploration of physics concepts. The entire research stage is shown in Figure 2.

The instruments used in this research include observation lists, interview guides, and video recording equipment. The observation checklist was designed to systematically capture participants' physical actions and techniques when holding *sumpit*. The interview guide consisted of open-ended questions to obtain detailed responses regarding the participant's knowledge and experience. Video recordings provide visual data to support observational findings and enable detailed analysis of the physical principles at work.

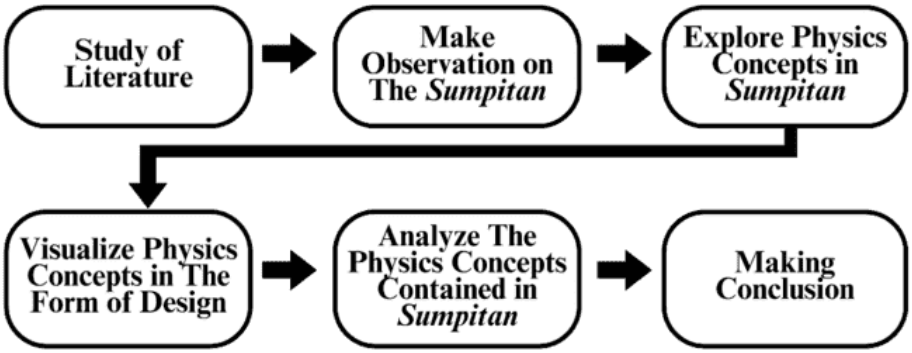

Figure 2. The reseach stages

The technique used in this research is data triangulation which consists of a process of direct interviews, observation, and literature study with the aim of strengthening the research results (Anam et al., 2019; Berg et al., 2018; Hardhienata et al., 2021). The data triangulation technique has the advantage of being able to strengthen research data, minimizing bias in research results, and being able to increase the internal validity of research (Farquhar et al., 2020; Nielsen et al., 2020). In general, data obtained through observations will be examined through a literature study process with the aim of checking the truth and strengthening the concepts studied. If there are similarities between the observation results and existing physics concepts, then this can strengthen the findings obtained. After that, the findings in the form of physics concepts according to the researcher's view will be analyse d according to the results of the literature review to strengthen the final findings. So, data collection through observation, interviews and literature study was then combined for overall analysis using a descriptive approach. This was done with the aim of looking at the research results and findings obtained (Dawadi et al., 2021; Farquhar et al., 2020; Flick, 2018).

▪ RESULT AND DISSCUSSION

Physics Concepts at the *Sumpit*

In general, there are two areas that contribute to the highest peak of sumpit, namely Kalimantan (Nusantara Islands) and the Indians from Orinoco and Amazon, especially the Jivaro Indian Tribe from Ecuador. The Indian tribes use blowguns as hunting tools and skillful games. The blowgun is made from naturally growing reeds, which are then filled with one-foot-long wooden arrows and a plug made of thistledown.

Figure 3. *Sumpit*

Sumpit Kalimantan is one of the traditional weapons of the Kalimantan society, especially the tribe of thrashers. It's almost the same in every district of Kalimantan. Generally, spears are used as weapons to hunt small animals and birds. Besides, it was also used as a weapon of war. Sumpit is used in war because it can be a secret weapon that can kill in secret (Darmadi, 2020). However, it is customarily not permitted to kill humans (Darmadi, 2018). So, in the time of colonization the sumpit used was a special weapon made for war. For the youth of the tribe of the Dayaks to be able to use a sumpit is an advantage, because if he is able to wear the sword well the young man is considered a knight. Therefore, the sword of Juda is often used as a popular game by the tribe of the Dayak.

Figure 4. *Sumpit* sports branch at FORMAS VII

In a crashing game, the youth of the Dayak Tribe must be able to shoot precisely and accurately at the target. The sumpit game is played outside the room so that the damak movements can be affected by the wind if the player's blows are not strong. So, when swinging, the strength of the blows will also be tested when using a sumpit. The stronger it blows, the faster it flows, so that it doesn't turn because of the wind. The evolution of the times did not make the sumpit lose its existence in the Kalimantan society especially the Tribe of the Dayak. Nowadays sumpit has become one of the traditional sports branches of the game played in every traditional sports week. Traditional Sports Week races are held on a regional, national and international scale. Besides, there is another traditional game that makes the sword one of the branches of its culture, namely the Erau KuKar Festival (Indonesia Kaya, n.d.), Pekan Dawai Dayak (Tempo.com, 2012), Turnamen Open Menyumpit (Sekertariat Kabupaten Kutai Barat, 2022), and there's a lot more.

On a set of sumpit there's a sumpit, a tulup, a damak, and a fabric covering the tulup. Sumpit is a long stick that is used in a blown, damak or saha is the arrows of wood or bamboo used to shoot a target, and a tulup or a telep used as a damak blade container so that the damak does not break or injure the user of the stake when stored. The structure of the sumpit is made of wood, stalk, plywood, straw, or plywood in the middle of it. The selection of these types of wood makes the sumpit stronger and straighter. The length of

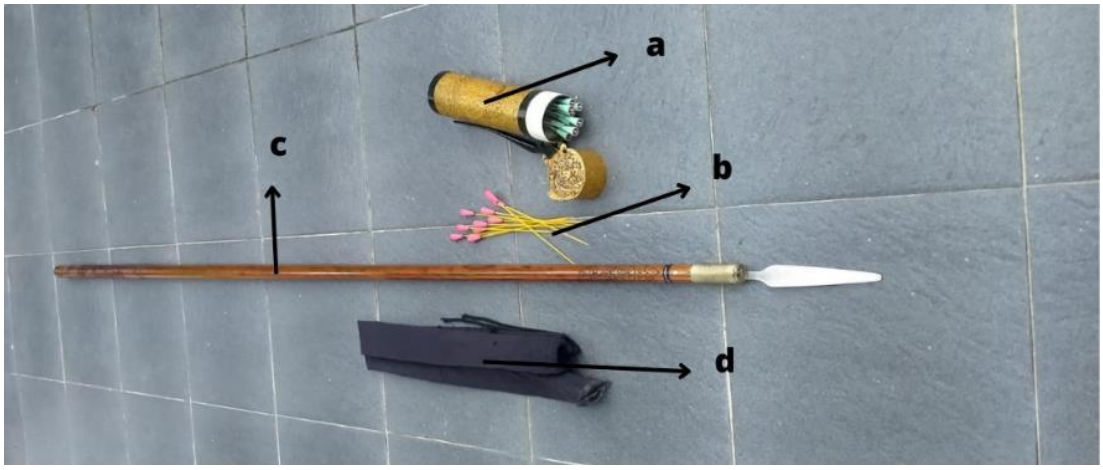

Figure 5. Kalimantan *sumpit* tool set (a) *Tulup/Telep,* (b) *Damak/Saha,* (c) *sumpit,* (d) *Tulup* covering fabric

the barrel is 1 - 3 meters, with an outer diameter of 2 - 3 cm, diameter in 1 - 2 cm, and weighs about 1.5 - 2 kg. At the end of the sumpit there are a spear and a rope made of iron. Spear and rope are tied with ropes made of wooden roots (usually those living in water or dew) or rope ropes. On the base of the sumpit there is a simple sumpit without a hose and there are those that are given the hose to make it easier for the user when it crashes. Next, a damak or saha used as an arrow when shooting. The damak is made of 15 cm hard wooden wool with a weight range of 5 grams. At the end of the damak will be covered with toxic fluids made from vegetable or animal fluids. At the base of the damak will be mounted fine fur that is usually made from animal fur. This fur serves to suppress the noise when the damak come out of the sumpit and reduce the droplet when the damak blow. Lastly, tulup or telep made of bamboo. The bamboo will keep the damak so that it doesn't get damaged by the worm.

Next, how to make a sumpit, there are three ways, namely, through the wire, using river currents, and drilling (Hidayanto, 2018). First make a sumpit with a wire. The reindeer is broken into small beams called rings, then the rings are hanged, then covered with wire from bottom to top. It takes three to seven days to produce a cane in this way. Second, using river currents. The refined wood is placed under a mine that is driven by a fan or a wooden turbine. It takes six to twelve months to make a sumpit using river currents. Third, with a special drill for making sumpit. After closing, iron will be placed on the inside of the hole so that the inside will be smoother and easier to stamp. Below, we will attach a simple process for making sumpit by a sumpit player from Bontang, East Kalimantan using a special tools. In this sumpit game you will explore physics concepts when playing swings which can be seen in Table 1.

Table 1. Exploring the physics concepts at the *Sumpit* usage stage

Condition	Physics Concept	Description of Physics Concept
Prefix Using Sumpit	Work	The work physics concept is reflected in the process of lifting the sumpit by both hands of the player. Force is applied to the butt end of the sumpit upwards by positioning them at eye level with the player. The

Condition	Physics Concept	Description of Physics Concept
		amount of work can be determined using the following equation. $$W = \tau \cdot \theta$$
Blowing Sumpit	Pressure	When a sumpit player inhales, a compressive force will occur on the lungs so that the cavity shrinks. Thus, the pressure that occurs on the player's chest is at maximum conditions. The amount of pressing force can be determined using the following equation. $$P = \frac{F}{A}$$
	Aerodynamics	When the player blows air into the sumpit, the air will flow through two different cross-sectional areas. This results in changes in air (fluid) speed and pressure. The velocity and pressure of the fluid when passing through two different pipe cross-sections can be determined using the following equation. $$Q = \frac{V}{t} = Av$$
Damak Moves Inside the sumpit	Aerodynamics	After the air is blown out, the air will enter the sumpit which has a smaller diameter than the diameter of the player's mouth. This results in changes in air volume and pressure. These changes in conditions can be explained using Bernoulli's law equation. $$P_2 + \frac{\rho}{2}{v_2}^2 + \rho g h_2 = P_1 + \frac{\rho}{2}{v_1}^2 + \rho g h_1$$
	Pull Force	Air thrust occurs due to changes in pressure and flow velocity in the damak so that the damak can move from its initial condition. The pushing force exerted by air can be explained through the following equation. $$P = \frac{F}{A}$$
	Friction Force	Friction occurs when the impact moves within the sumpit cavity causing the impact to rub against the diameter of the inner surface of the sumpit. The magnitude of its occurrence can be minimized by providing feathers or foam at the back end of the damak. $$F_k = \mu_k N$$
	Momentum	When the damak moves in the sumpit, the damak has speed. Because the damak is an object that has mass, the damak motion there is the concept of momentum. $$p = mv$$
	Kinetic Energy	As time goes by, there is a change in the speed of the damak in the sumpit. so that the damak has kinetic energy. A moving object will have kinetic energy. Kinetic energy is energy that is affected by the speed of an object. $$Ek = \frac{p^2}{2m}$$

Condition	Physics Concept	Description of Physics Concept
Damak Came Out of the sumpit	Parabolic Motion	When the damak comes out of the sumpit, the damak will experience a parabolic motion due to the influence of gravitational force. So the player needs to form a slight axis so that the damak can be shot straight at the target. To find out the angle formed by the player, the following equation can be used. $$\tan\theta = \frac{v_y}{v_x}$$
	Time Travel and Maximum Distance of Damak	When the damak is ejected from the sumpit in a parabolic trajectory, the impact will travel a maximum distance at a certain angle with a travel time that can be determined using the following equation. $$x_{max} = v_x t_{xmax}$$
	Sound Waves	When the damak comes out of the sumpit, the air in the sumpit will make the inner cavity of the sumpit vibrate and produce a sound. Sound is a wave that can propagate through a medium. The intensity of the sound emitted by sumpit can be seen in the following equation. $$I = \frac{P}{4\pi R^2}$$
Damak Hit the Target	Simple Machines	To be able to stick into the target board, the tip of the damak must be sharp. The sharper the edge of the damak, the easier it is for the damak to stick into the target board. This can be called the mechanical advantage of sharp objects, which corresponds to the concept of a simple machines. $$KM = \frac{s}{h}$$
	Inelastic Collision	When the Damak comes out of the sumpit, the damak will collide with the target surface. Some of the kinetic energy from the damak will be converted into elastic potential energy when the collision occurs. After the collision, the damak will move at a lower speed than the original speed. $$m_1 v_1 + m_2 v_2 = m'_1 v'_1 + m'_2 v'_2$$ $$v'_2 - v'_1 = e(v_1 - v_2)$$

Table 1 describes the physics concepts used in each condition. Furthermore, the physics concept of each stage performed when using sumpit will be explained. First, the condition when prefix using sumpit. When the player makes the initial movement to sumpit, there are several physics concepts that are used. these concepts include. First, the concept of work. The process of using the sumpit begins with lifting the sumpit. The tip of the sumpit touches the ground and both hands grip the base of the sumpit. How to lift the sumpit by applying force to the base of the sumpit upwards until it is above the eye, then lowering it slightly until it is level with the eye and the shooting target. This makes the blower's hand stronger and more stable in shooting.

(a) (b)

Figure 6. Initial position holding the *sumpit* (a) The *sumpit* player lifts the sumpit and (b) Illustration of the work concept with the integration of the moment of force concept in it

The way to lift the sumpit is related to the work concept. Work is the amount of force required to make a movement (Abdullah, 2016; Gould & Tobochnik, 2021; Mansfield & O'sullivan, 2020). When lifting the sumpit, the work done by the player is done in rotation. So, the equation used will be slightly different from the work equation for objects in linear motion. The equation for work in circular motion can be seen in equation 1. An object that rotates about a fixed axis, such as a pulley, can be said to do work by changing a certain angle (Giancoli, 2014).

$$W = \tau \cdot \theta \qquad (1)$$

Next, an explanation of the physics concept that occurs in the condition when blowing sumpit. First, concept of pressure. When a sumpit player inhales, a compressive force will occur on the lungs so that the cavity shrinks. Thus, the pressure that occurs on the player's chest is at a maximum (lung volume is at a minimum). This situation will be inversely proportional when the sumpit player expels the air. When the air that the player inhales is expelled, the lungs will expand so that the compressive force that occurs in the lungs is at a minimum (lung volume is at a maximum). The amount of compressive force on the lungs can be determined using the following equation.

$$P = \frac{F}{A} \qquad (2)$$

Second, explaining about concept of aerdynamic. How to blow a sumpit can be explained using the concepts of aerodynamics. Before air enters the sumpit, the sumpit player will reserve a certain amount of air in the chest cavity or oral cavity. When the player is ready to throw the damak, the air will be pushed as hard as possible from the mouth cavity towards the sumpit. Thus, the air flowing from the oral cavity to the sumpit will experience a change in speed due to reduced air flow passing through it (Fuadi et al., 2018).

Figure 7. Fluid discharge during the blowing movement of a *Sumpit.*

If we analyse using the aerodynamics concept, we can find out the speed of air passing through the sumpit cavity due to changes in the diameter of the cavity through which the air passes. The one blow technique makes the volume of air entering the sumpit cavity equal to the volume of air from the player's mouth. This fulfills the concept of the law of continuity, the amount of air volume that passes through the area along the cavity has a constant value (Halliday & Resnick, 2011).

$$v_2 = \frac{{d_1}^2}{{d_2}^2} v_1 \qquad (3)$$

We can assume that the diameter of the player's mouth (d1) is the same as the outer diameter of the sumpit and the sumpit diameter (d2) is the same as the inner diameter of the sumpit. So this equation can be solved as.

$$v_2 = 4v_1 \qquad (5)$$

Where v1 is the initial fluid velocity or the speed of the air blown from the player's mouth. After knowing the speed of the fluid passing through the sumpit, we can find out the compressive force exerted by the fluid or air on the damak, so that the damak can move inside the sumpit and be ejected out.

Furthermore, the explanation of the physics concept during the condition of the damak moving inside the sumpit. The first concept that use during of damak motion is aerodynamics. The fluid pressure on the sumpit can be observed using the concept of Bernoulli's law. Bernoulli's law states that the pressure of a fluid decreases as the fluid's speed increases (Serway & Jewett, 2014). Bernoulli's law equation can be seen in the following equation.

$$Q = P + \frac{\rho}{2} v^2 + \rho g h \qquad (6)$$

By applying the principle of conservation of energy to fluids, we will show that these quantities are related by

$$P_2 = \frac{\rho}{2}({v_2}^2 - {v_1}^2) + \rho g(h_2 - h_1) + P_1 \qquad (7)$$

Substitute the result from equation (5) into equation (7), so that

$$P_2 = \frac{\rho}{2}\left(15{v_1}^2\right) + \rho g(h_2) + P_1 \qquad (8)$$

The pressure that occurs in the damak is caused by changes in the volume through which the fluid passes. This pressure will provide a pushing force to the damak, so that the damak can move along the sumpit cavity. Next, is concept of pull force. As a result of this pull force, the damak will flow inside the sumpit, because it is unable to withstand the pressure exerted by the fluid.
The pressure at the damak can be found using the following equation

$$F = PA \qquad (9)$$

Substitute the pressure value (P) from equation (9) into equation (10), so that

$$F = \left(\left(520\,\frac{kg}{m^3}\right)\left(15{v_1}^2\right) + \left(10192\ \frac{kg}{m^2 s^2}\right)(h_2) + P_1\right)(0.011775\ m^2) \qquad (10)$$

As long as the damak flows in the sumpit hole, the damak will experience a frictional force. Therefore, when making *sumpit* you have to be very careful so that the holes in the sumpit are straight and even. If the sumpit holes are uneven, they will experience a lot of friction. So, at the bottom end of the traditional *damak*, feathers are provided which are useful for reducing friction and droplets when blowing on *sumpit* (Janich, 1933). Friction can cause the damak to slow down and cause noise. The friction force that acts between the *damak* and the inner surface of the *sumpit* can be described as follows.

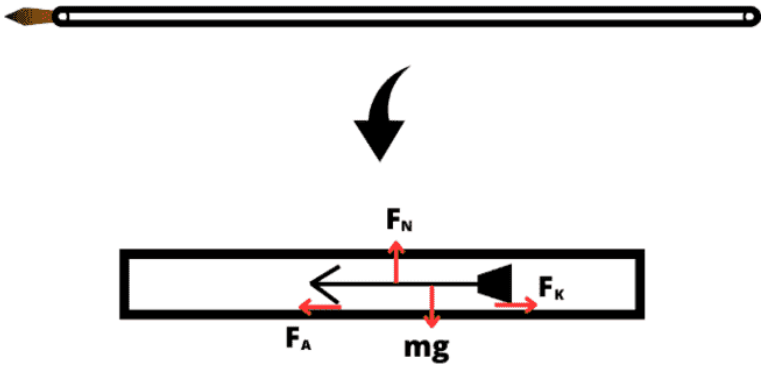

Figure 9. Friction force vector on *Sumpit*

The frictional force that acts between the damak and the inner surface of the sumpit is kinetic friction, namely friction that occurs between two surfaces of solid objects that tend to move (Giancoli, 2014; Halliday & Resnick, 2011; Serway & Jewett, 2014). So we can use equation (11) to describe the magnitude of the kinetic friction force experienced by the *damak.*

$$F_k = \mu_k N = 0.0196\ N \qquad (11)$$

Making the sumpit narrow in diameter has the function of increasing the speed of fluid flow in the sumpit. So, the damak moving in the sumpit will move at high speed along the track and can be thrown far to the shooting target. When the sumpit is ejected, there is the concept of momentum and kinetic energy in the damak, as a result of the air pressure when the sumpit is blown. Momentum occurs when an object with mass moves at a certain speed (Serway & Jewett, 2014). The momentum of the damak can be explained through the following equation. If the average travel speed of the damak is 90 m/s, then the damak momentum can be known, as follows

$$p = mv = 0.45\ kg\,\frac{\mathrm{m}}{\mathrm{s}} \qquad (12)$$

As a result of the *damak* moving, the impact has kinetic energy. Because kinetic energy is energy related to the movement of particles (Young et al., 2008). From the *damak* impact momentum we can find out the kinetic energy of the *damak.* By substituting the momentum value obtained in equation (12) and the mass of the *damak*, we can find out that the *damak* has when it is ejected from the *sumpit*.

$$Ek = \frac{p^2}{2m} = 20.25\ J \qquad (13)$$

The energy released is large enough to be used for hunting, plus the sharp shape of the *damak* makes it easy for the *damak* to stick into the prey target. After analysing the concept of physics when the damak moves inside the *sumpit*. Next, analyse the concept of physics that occurs when the damak is ejected out of the *sumpit*. Finally, the damak will be ejected from the sumpit and hit the target. The aim of the sumpit must be at eye level so that it hits the target precisely. This means that the tip of the *sumpit* must be raised at a certain angle. This method can be explained in the physics concept of parabolic motion. Every object that is given an initial speed and moves along a certain path will be affected by air friction and gravitational acceleration (Young et al., 2008). Parabolic motion can be studied by unit vector analysis, vector analysis of parabolic motion on a *sumpit* is given in the following image.

The parabolic motion of the sumpit can be seen when the damak comes out of the sumpit due to the compressive force from inside the sumpit. So, that the ejected damak forms a semi-parabolic trajectory. In Figure 10 the x-axis and y-axis are at the point where the damak starts to move. At this point we set t = 0. The initial speed when the damak comes out as v3, θ0 is called the elevation angle. If the initial velocity is decomposed into

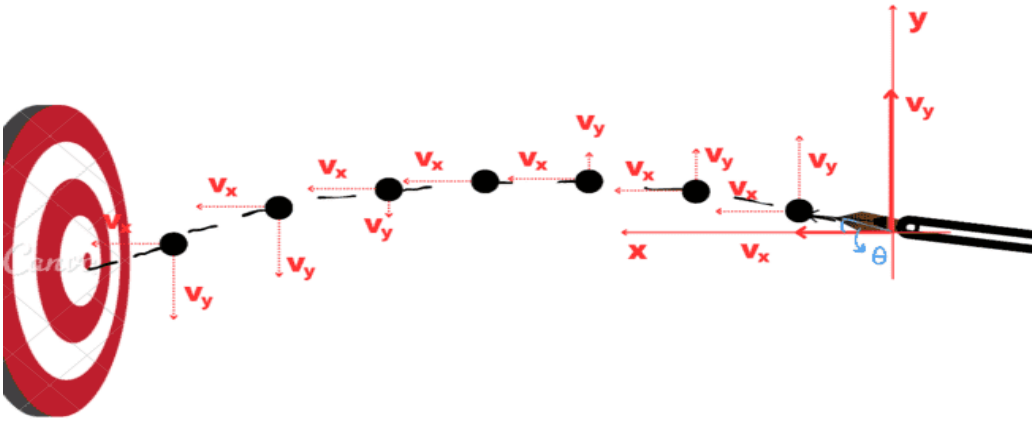

Figure 10. *Damak* parabolic motion trajectory

horizontal components v3x with amount v3 cos θ0, and vertical component v3y with amount v3 sin θ0. So,

$$v_x = v_{3x} = v_3 \cos\theta_0 \qquad (14)$$

Damak's vertical acceleration is -g so the vertical velocity component at time t is

$$v_y = v_{3y}\ gt = v_3 \sin\theta_0\ \ gt \qquad (15)$$

So the resultant speed of the damak can be described by the following equation.

$$v_3 = v = \sqrt{v_x^2 + v_y^2} \qquad (16)$$

An illustration of the use of sumpit can be seen in the figure 11.

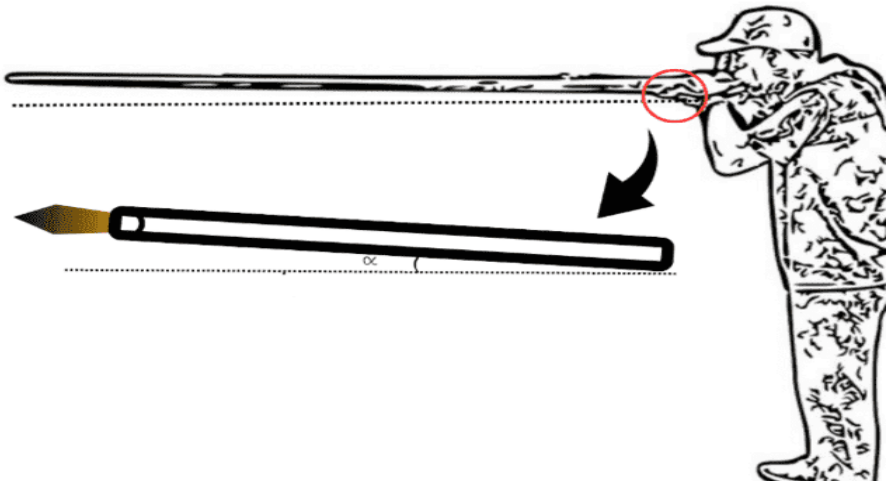

Figure 11. The angle formed on the *sumpit* is towards the user's eyes

If you look briefly, the sumpit does not form an angle but is straight with the target. This happens because the length of sumpit reaches 2 meters, with the angle between the target and the user's eyes being very small, so the angle is not visible. In accordance with the theory of motion of objects, an object moving on the surface of the earth will be influenced by the force of gravity (Young et al., 2008). So, the object will tend to move down on the vertical axis. By raising the sumpit slightly, you can reduce the impact of the damak not hitting the target, due to the damak moving downwards. And the angle it makes with the x-axis as follows.

$$\tan \alpha = \frac{v_y}{v_x} \qquad (17)$$

The travel time and maximum distance that the damak can travel can be calculated using the equation of parabolic motion. By calculating the maximum throwing distance, we can find out the shooting capability of the sumpit. To find out the maximum distance traveled from the damak, you can use the following equation (Young et al., 2008). To achieve the maximum distance, the angle set must be at a value of 45°.

$$x_{max} = 2066.41\ m \qquad (18)$$

To find out the travel time from the damak to reach the maximum distance, you can use equation (19).

$$t_{x\ max} = \frac{x_{max}}{v} = 10.27\ s \qquad (19)$$

When the damak is ejected from the sumpit there is no sound emitted by the sumpit. This prevents game animals from running away when using sumpit to hunt. In fact, when the damak is ejected, a sound is still emitted, but the sound waves that come out can be dampened by the hairs at the back end of the damak. Sound waves are waves that allow us to hear and make sounds (Hidayat, 2019). As mechanical waves, sound waves cannot propagate in a vacum (Young et al., 2008).

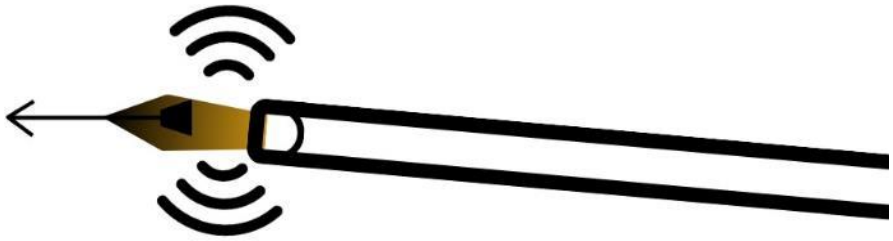

Figure 12. Sound waves coming out of *Sumpit*

The size of the sound waves produced by sumpit is influenced by the intensity of the sound. The equation for sound intensity can be seen in the following equation.

$$I = \frac{P}{4\pi R^2} \qquad (20)$$

Finally, it analyses the physics concept of what happens to the damak when it hits the target. The shape of the tip of the damak also influences the condition of the damak when thrown. By making the tip of the drum sharp, it can reduce the force needed by a sumpit player to blow their sumpit. This can be explained through the concept of a simple plane.

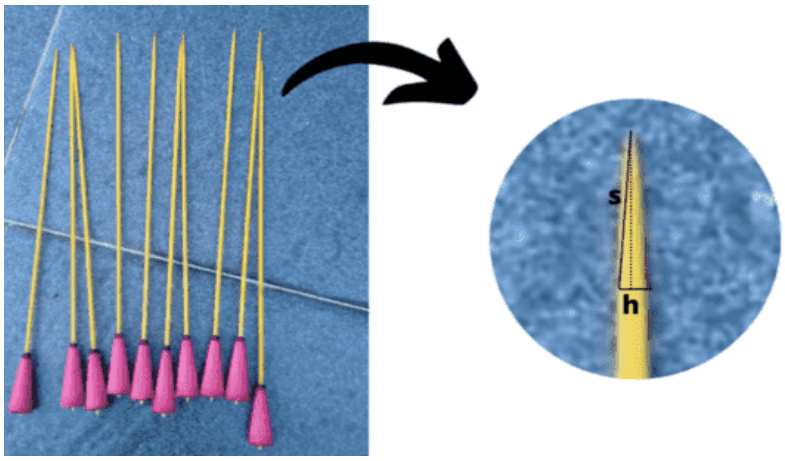

Figure 13. Mechanical advantage

Because the ends of the damak form a triangular shape, the appropriate concept is a simple plane on an inclined plane (Young et al., 2008). The mechanical advantage of the damak tip is the same as the mechanical advantage of a simple inclined plane. It can be seen in the following equation.

$$KM = \frac{s}{h} \qquad (21)$$

So, the mechanical advantage possessed by the damak is influenced by the width or diameter of the damak and the slope of the damak. In the end, the damak will be stuck on the target board. With the correct estimate of the angle and force of the blow, the damak can hit the target.

Figure 14. Inelastic collision

When the damak is stuck on the target, the damak and the target collide. The type of collision that occurs is a partially elastic collision, because after the collision occurs, the damak that collides with the target board does not return to moving at its original speed. Some of the kinetic energy possessed by the damak turns into elastic potential energy after the collision (Young et al., 2008). To prove that the impact experienced a partially elastic collision, you can use equation (22). If the value of the coefficient of restitution (e) is 0, then the damak experiences an inelastic collision.

$$m_1 v_1 + m_2 v_2 = m'_1 v'_1 + m'_2 v'_2$$
$$v'_2 - v'_1 = e(v_1 - v_2) \qquad (22)$$

We can assume that v2 is the damak speed and v1 is the target board speed. In this situation, the target board does not move so it has no speed or v1 = 0. Meanwhile, the speed of the damak after the collision is 0, this can be seen from the condition of the damak that stops and sticks to the target board. So equation (22) can be as follows.

$$e = \frac{0}{-v_2} \qquad (23)$$

Based on the rules of number operations, all numbers that divide 0 will produce the number zero (0).

$$e = 0$$

So, the magnitude of the restitution constanta is 0, which proves that the impact condition when colliding with the target board is an inelastic collision.

▪ CONCLUSION

Based on the results and discussion, it can be concluded that in traditional Kalimantan "Sumpit" weapons, every movement and condition that occurs while chopping can be studied physically. The physics concepts contained in traditional Kalimantan chopstick weapons are pressure, fluid dynamics, thrust force, friction force, momentum, kinetic energy, parabolic motion, and collision. The results of this research show that there is potential for physics learning media with the local wisdom of traditional Kalimantan "Sumpit" weapons. Learning physics with ethnoscience will help students improve their understanding and learning outcomes, and students will be more interested and motivated to study physics and local wisdom simultaneously. Suggestions for future researchers to study in more depth and look for more references related to the physics concepts found in traditional Kalimantan "Sumpit" weapons, as well as studying other local cultures. Studies of different regional cultures can be carried out to facilitate contextual understanding of material on various subjects and preserve Indonesian culture. A part from that, developing research to be implemented into learning, so that the physics concepts obtained can be realized in real life in education in Indonesia.

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