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Ethnophysics Literature Study of "Tarik Tambang" and "Balap Karung" in the Application of Newton's Law Physics Concepts

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Abstract

This study aims to examine the physics concepts embedded in the traditional Indonesian games *Tarik Tambang* (Tug of War) and *Balap Karung* (Sack Race) through the application of Newton's Laws. Conducted within the framework of ethnophysics, the research seeks to bridge scientific principles with local wisdom to foster contextual and engaging physics learning for students. A qualitative approach utilizing literature review was employed, analyzing various scholarly sources related to traditional games and their underlying physical principles. The findings reveal that *Tarik Tambang* illustrates Newton's Second Law of Motion and the role of static friction. The game demonstrates how the acceleration of the opposing team is determined by the net pulling force and total system mass, while static friction is essential for maintaining player balance and traction. Additionally, strategies such as placing heavier players at the back enhance force generation and overall team performance. In *Balap Karung*, Newton's Third Law and momentum significantly influence participants' movements. The forward propulsion results from the backward action force exerted by the feet, which is met with an equal and opposite ground reaction force. Momentum affects the stability and speed of the jump, and friction between the sack and ground determines the efficiency of motion. This research highlights the pedagogical potential of traditional games in physics education. By contextualizing Newtonian mechanics through culturally familiar activities, students can develop a more concrete understanding of physical laws. The study recommends incorporating such games into instructional strategies to promote meaningful and culturally responsive science learning.

Keywords: Ethnophysics; Traditional games; Tarik tambang; Balap karung; Newton's laws.

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INTRODUCTION

Traditional games represent a valuable facet of Indonesia's cultural heritage, passed down through generations and embodying local wisdom, social values, and implicit educational content (Febrianty et al., 2023). Indonesia is estimated to have around 60 to 241 types of traditional children's games, depending on the source, each rich with potential to be integrated into educational frameworks—especially in science and physics learning (Asra et al., 2021). These games, embedded in the daily lives of local communities, offer not only entertainment but also multidimensional educational benefits, including physical, cognitive, and social skill development.

The interdisciplinary field that bridges physics with indigenous cultural practices is known as *ethnophysics* (Nurhidayat et al., 2020). Ethnophysics aims to examine local wisdom in the form of traditions, beliefs, and community practices through the lens of physical laws and scientific reasoning (Wulansari & Atmoko, 2021). This approach has become a compelling educational strategy, particularly in contexts where scientific concepts are often perceived as abstract or disconnected from students' lived experiences. Among the cultural expressions studied in ethnophysics are traditional dance, rituals, and notably, traditional games (Nurmasyitah et al., 2022). Leveraging these local practices in the physics classroom has proven effective in enhancing student interest, engagement, and comprehension (Astuti & Bhakti, 2021).

Modern physics education in Indonesia often remains focused on textbook-based instruction, limiting the connection between scientific content and students' cultural environment. As noted by Rizaldi et al. (2014), physics learning tends to overlook the relevance of students' lived realities, thus failing to tap into the rich cultural resources surrounding them. This detachment poses challenges for both comprehension and student motivation, particularly in abstract topics such as Newton's Laws of Motion.

To address this issue, integrating traditional games as contextual learning tools provides a promising pedagogical pathway. Games such as *Tarik Tambang* (tug of war) and *Balap Karung* (sack racing) serve as culturally relevant platforms through which fundamental physical principles can be demonstrated in tangible and relatable ways. These games not only encourage active learning but also embody Newtonian mechanics in their inherent mechanics of force, motion, and reaction. As such, they offer a practical and meaningful entry point for teaching physics in a culturally inclusive and conceptually clear manner.

Prior studies have highlighted the effectiveness of incorporating local wisdom and traditional games in physics instruction. Astuti and Bhakti (2021) observed that traditional games foster better conceptual understanding among students by linking theoretical content with observable phenomena. Similarly, Ady et al. (2024) demonstrated that such integration significantly enhances students' logical thinking skills, indicating that traditional games can support cognitive development alongside content mastery. Their findings reinforce the premise that instructional strategies rooted in cultural relevance tend to yield more effective learning outcomes.

Further, the use of traditional games such as *Tarik Tambang* and *Balap Karung* has been recognized as pedagogically sound due to their natural embodiment of Newton's Laws. In *Tarik Tambang*, Newton's Second Law of Motion becomes evident in the acceleration of the rope and participating teams in relation to net force and mass (Santoso & Setiabudi, 2020). The game vividly illustrates the concept of resultant force and its effect on motion, thus serving as a live demonstration of the law's applications. Similarly, *Balap Karung* encapsulates Newton's Third Law of Motion—every action has an equal and opposite reaction—through the jumping movement of participants, whose push against the ground results in vertical displacement, governed by reaction forces and momentum.

Nonetheless, these traditional games are rarely utilized in formal education contexts. Existing studies mostly examine their cultural or recreational values, and only a limited number systematically analyze them through the lens of physics, especially Newtonian mechanics. This gap calls for a more structured exploration of how these culturally embedded activities can function as instructional media in physics education.

Although several researchers have advocated the use of ethnoscience and local culture in science learning, there remains a significant gap in the systematic analysis of specific games in terms of discrete physics concepts. For example, studies by Nurmasyitah et al. (2022) and Wulansari & Atmoko (2021) suggest the potential of traditional games in physics instruction but lack specific investigations into the mechanics of particular games. Moreover, while the educational advantages of such integration have been frequently asserted (Astuti & Bhakti, 2021; Ady et al., 2024), most do not rigorously contextualize these games within defined laws of physics, such as Newton's Laws.

Furthermore, *Tarik Tambang* and *Balap Karung* are still underexplored in terms of their utility as learning tools. No comprehensive study to date has categorized and detailed the physical forces at play in these games in alignment with Newtonian mechanics. This oversight leaves a void in both theoretical elaboration and practical application in classroom settings. As emphasized by Rizaldi et al. (2014), any integration of traditional games into educational practices must be preceded by thorough philosophical and cultural analysis—a criterion not yet fully met in the case of these two games.

The primary objective of this study is to explore the application of Newton's Laws of Motion in traditional Indonesian games, specifically *Tarik Tambang* and *Balap Karung*, through a structured literature review. This study seeks to analyze the mechanics inherent in these games, identify their alignment with Newtonian principles, and discuss their potential as educational tools in physics learning environments. The research is rooted in the ethnophysical framework, aiming to bridge local cultural practices with scientific inquiry to foster more meaningful and contextual learning experiences.

The novelty of this work lies in its focus on two underutilized traditional games as direct representations of Newtonian physics. Unlike previous studies that discussed traditional games broadly or focused on cognitive gains from cultural integration, this paper targets the explicit mapping of game dynamics to Newton's First, Second, and Third Laws of Motion. This approach offers a unique pedagogical perspective that is both culturally resonant and scientifically rigorous.

METHODS

This study employed a qualitative approach through the use of library research methodology. As emphasized by Zed (2008), literature studies aim to explore and synthesize various written sources to construct a strong theoretical foundation for the research. Beyond forming the basis of theoretical understanding, literature studies also play a critical role in identifying research gaps and directions for further investigation. This methodological orientation was chosen to allow a comprehensive and contextual analysis of the scientific principles embedded in traditional games, particularly *Tarik Tambang* and *Balap Karung*, within the framework of ethnophysics.

The data collection technique was based on a systematic review of literature relevant to the topics of ethnophysics, traditional games, and Newtonian physics. Sources included peer-reviewed scientific journals, academic books, and relevant research reports that discuss the application of physical concepts in cultural contexts. The process involved selecting documents that explicitly or implicitly described physical phenomena present in traditional game activities, with specific attention to those that align with Newton's Laws of Motion. This method ensured the incorporation of both theoretical perspectives and empirical findings into the analysis.

The data analysis was conducted using a descriptive-qualitative approach. This entailed classifying the identified physical concepts and interpreting their occurrences in the activities of *Tarik Tambang* and *Balap Karung*. The analysis focused on four main physics principles: force, mass, acceleration, and momentum, which are foundational to Newtonian mechanics. The interpretation involved mapping these principles onto the physical movements and interactions observed or described in the games, thereby making the implicit physics concepts explicit and pedagogically accessible.

Finally, the findings from the literature review were synthesized to draw conclusions regarding the feasibility and value of using these traditional games as instructional media in physics education. The aim was not only to bridge cultural practices with scientific principles but also to promote a more contextual, engaging, and culturally responsive approach to learning physics. This methodological framework supports the integration of traditional knowledge into modern curricula, offering a pedagogical model that aligns local heritage with global scientific understanding.

RESULTS AND DISCUSSION

Tarik Tambang (Tug of War)

According to Subagiyo (as cited in Agustina, 2022), traditional games are forms of play that emerge and evolve within a specific cultural community. *Tarik Tambang* is one such traditional game, where two opposing teams pull on a rope in opposite directions until the center knot of the rope is drawn past a predetermined boundary line. A team is declared the winner when it successfully pulls the opposing team beyond this line, thereby scoring a higher point (Athirah et al., 2023). Each team is composed of multiple players who cooperate and synchronize their efforts to exert a greater pulling force than the opposing team.

There are no strict rules governing the number of participants per team, as long as both teams are evenly matched. *Tarik Tambang* is inclusive and can be played by people of all age groups, from children to adults. It requires only a modest playing area, such as a small field or open ground. Importantly, *Tarik Tambang* can be utilized as a contextual learning tool in physics education to help students grasp the concepts of force and motion. The game not only provides entertainment but also illustrates fundamental principles of physics that are observable in real time. Through active participation, students can directly experience how forces operate, which facilitates a deeper understanding of Newton's Laws of Motion, particularly those related to force and acceleration.

In the context of *Tarik Tambang*, several factors contribute to a team's success, such as the number of players, individual physical strength, coordination among team members, and the friction between the players' feet and the ground. When a team is able to generate a stronger pulling force and maintain equilibrium, the opposing team may be displaced or even lose their footing. Consequently, the team that exerts the greater and more stable force ultimately emerges as the winner.

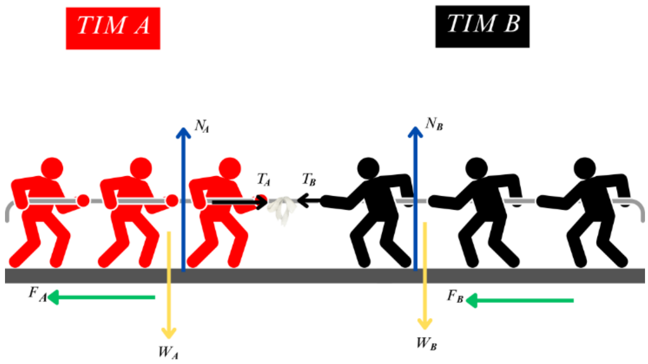

Figure 1. Force analysis acting in *Tarik Tambang*

In Figure 1, two opposing teams are shown pulling the rope in opposite directions. Each player in the illustration is subjected to several key forces that influence their motion and balance throughout the course of the game. These forces include the gravitational force (weight), the normal force, frictional force, and the tension in the rope. One of the dominant forces illustrated is the pulling tension force denoted as T_A, which is exerted by the players of Team A on the rope. This force is critical in determining the direction of the rope's movement and directly affects the opposing team's balance. The greater the pulling force exerted by a team, the higher the probability that they will overcome the opposing team and pull them across the victory line.

On a rough surface, two additional forces play significant roles—friction and normal force. For example, in Team A, the frictional force is denoted as f_A, which aids in anchoring the feet to the ground and contributes to the backward pull. The normal force (N_A) is exerted by the ground on the feet of Team A's players, acting perpendicular to the contact surface. This force balances the players' weight and prevents them from sinking into the ground.

When one team applies a net pulling force *F* that is greater than the force exerted by the opposing team, acceleration aaa occurs in the direction of the stronger team. This phenomenon aligns with Newton's Second Law, which states that the acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass. This relationship is represented by the equation:

$$\Sigma F = m.a$$

If $F_A > F_B$, the rope and consequently the players are accelerated toward Team A, as given by the equation:

$$a = \frac{F_A - F_B}{m}$$

Where *m* represents the total mass of the system, including the rope and the players being pulled. Therefore, the greater the force differential, the greater the acceleration toward the stronger team. This also explains why teams strategically place heavier players at the rear—individuals with larger body mass contribute significantly to the total force and system stability. This tactic aligns with findings from Santoso & Setiabudi (2020), who reported that such positioning enhances competitive advantage in *Tarik Tambang*.

To maintain balance and prevent slipping while pulling the rope, players rely heavily on static friction (f_s) between their feet and the ground. This frictional force is defined by:

$$f_s = \mu_s N$$

Where μ_s is the coefficient of static friction, and NNN is the normal force. If the pulling force F_t exceeds the maximum static frictional force $f_{s,max}$, the player will slip. Hence, players often lean backward to increase the pressure on their feet, thereby increasing the normal force N and, subsequently, the static friction. This maneuver allows for a stronger grip on the surface. By doing so, players maximize the effect of static friction, often using their heels to resist the opponent's pull—a strategy that engages the lower body muscles, particularly the legs, as highlighted in the research by Santoso & Setiabudi (2020).

These findings reveal that *Tarik Tambang* is not only a traditional recreational activity but also a demonstrable model of physical principles. The observable relationship between applied force, mass, friction, and acceleration allows students to experience the applications of Newton's Laws in a real-world context. Scientifically, this supports the pedagogical integration of culturally rooted games into physics education. The game provides a structured environment to observe and analyze how different variables interact dynamically, explaining not only the mechanics behind success in the game but also reinforcing the core tenets of classical mechanics in a tangible, engaging manner.

Balap Karung **(Sack Race)**

Balap Karung is one of the most popular traditional games during Indonesia's Independence Day celebrations. The rules of the game require each participant to place the lower half of their body into a sack and race to the finish line. Participants must maintain their grip on the sack at all times and ensure the sack does not come off their body. The technique of movement is flexible as long as the player remains inside the sack. Some participants hop with both feet, others proceed slowly by shuffling, or even attempt to run. The most common method, however, is hopping. Falling is a frequent occurrence, but participants are expected to get up quickly and continue the race. Importantly, players must not obstruct or collide with each other during the competition (Munir, 2019).

Figure 2. *Balap Karung* (sack race) competition

From a physics perspective, the movements involved in *Balap Karung* can be analyzed using Newton's Laws of Motion. When a participant hops, their feet—confined within the sack—push backward against the ground. According to Newton's Third Law, for every action there is an equal and opposite reaction: the ground exerts a forward reaction force of equal magnitude that propels the participant forward. The greater the backward force exerted by the feet, the greater the resulting forward acceleration. The point where the foot makes contact with the ground is known as the pivot point, where the main force interaction occurs and which plays a critical role in maintaining body balance during the jump. Based on this analysis, it can be concluded that the interaction of forces during the race aligns precisely with Newton's Third Law: "For every action, there is an equal and opposite reaction" (Safitri et al., 2023).

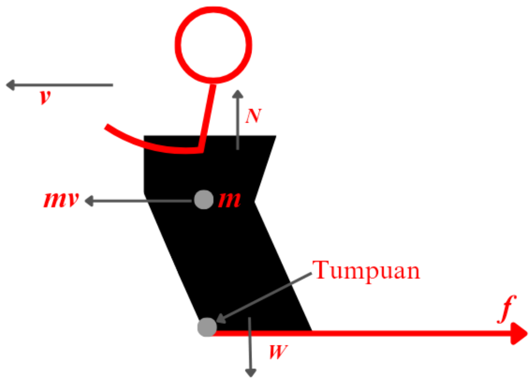

Figure 3. Analysis of physics concepts in sack racing (*Balap Karung*) competitions

The sequence of motion in *Balap Karung* can be broken down into four phases:

1. Initial Phase (Pre-jump): The participant bends their body and knees to store potential energy in the leg muscles. During this phase, weight and normal force are balanced, while static friction prevents slipping.
2. Jumping Phase: The legs extend forcefully against the ground at a certain angle from the horizontal, producing an upward and forward motion. The initial velocity consists of both vertical and horizontal components.
3. Aerial Phase (Projectile Motion): After take-off, the participant follows a parabolic trajectory. The horizontal velocity component remains constant (assuming air resistance is negligible), while the vertical component decreases due to gravitational acceleration.
4. Landing Phase: Upon landing, the feet absorb the impact via a reaction force from the ground. Kinetic friction acts to decelerate forward movement just before the next jump is initiated.

Furthermore, each participant exhibits a velocity (*v*) that indicates how fast they are moving forward. This velocity results from the repeated leg thrusts that generate forward momentum. Momentum—defined as the product of mass and velocity—is a vector quantity whose direction is determined by the direction of motion (Fitrianingrum & Kamaruddin, 2023). The greater the participant's mass or speed, the more momentum is generated, making it more difficult to stop the motion.

Additionally, movement is affected by frictional forces between the sack and the ground. This friction is crucial for providing a stable base for propulsion. If the friction is too low—such as on a tiled or smooth surface—participants may struggle to push off effectively or may slip easily. On the other hand, excessive friction can impede motion, causing the movement to become sluggish due to increased resistance from the ground surface. *Balap Karung* is not only a culturally rich activity but also a practical demonstration of various physics concepts, including action-reaction forces, momentum, and the roles of static and kinetic friction. Through its analysis, students are given the opportunity to observe and experience these principles in a real-world, engaging context, reinforcing their understanding of Newtonian mechanics in a culturally meaningful way.

The analysis of *Tarik Tambang* and *Balap Karung* demonstrates how Newton's Laws of Motion can be meaningfully interpreted through traditional games, thereby aligning with the study's focus on identifying physics concepts within cultural practices. The investigation reveals that both games inherently exhibit fundamental principles such as force equilibrium, action-reaction pairs, acceleration, and momentum. These findings provide a contextual bridge between abstract physics theories and observable, everyday phenomena, making them more accessible for students. By embedding these traditional activities into physics learning, the material becomes not only more engaging but also more relevant to students' lived experiences.

This study contributes to educational strategies that support culturally responsive teaching. The ability of traditional games to model classical mechanics offers a dual advantage: promoting conceptual understanding of physics while simultaneously preserving and valuing local heritage. This supports the development of integrated learning environments in which scientific knowledge and cultural identity are not seen as separate domains, but rather as complementary elements in holistic education. As a result, the use of traditional games such as *Tarik Tambang* and *Balap Karung* has the potential to enrich physics instruction, enhance student motivation, and foster deeper cognitive connections to core scientific concepts.

The analysis further reinforces that traditional games serve as a medium through which students can observe and experience scientific principles embedded in cultural practices. As Astuti et al. (2022) emphasized, ethnophysics effectively bridges cultural context with physical concepts, enhancing student engagement by rooting learning in familiar experiences. Similarly, Rahmat et al. (2024) highlight that embedding local cultural values into science education increases the subject's relevance and invigorates classroom dynamics. These insights underscore the importance of leveraging cultural assets as a vehicle for learning, particularly in subjects like physics that are often perceived as abstract or disconnected from daily life.

Engaging with games like *Tarik Tambang* and *Balap Karung* also aligns with the principles of experiential and holistic learning advocated by Oosman et al. (2019). Such culturally relevant pedagogy allows students to perceive physics not just as a theoretical discipline, but as a living knowledge system that is intertwined with their community's heritage. By integrating these games into instructional practice, educators provide learners with an immersive environment where cultural familiarity supports the comprehension of scientific phenomena. This strategy fosters both cognitive and affective dimensions of learning, strengthening the students' ability to connect personal identity with academic content.

Moreover, as noted by Handayani et al. (2018), the contextualization of scientific concepts through local games significantly improves learning outcomes by making abstract knowledge more tangible and relatable. This integration enhances students' ability to internalize and apply scientific principles, bridging the gap between academic frameworks and real-life applications. The combined findings affirm that incorporating cultural elements into physics education contributes to a more inclusive and effective learning experience.

Finally, Pereira et al. (2022) emphasize that embracing local cultural contexts in education not only supports cognitive development but also fosters a deeper appreciation for heritage, thereby contributing to students' broader human development. This perspective aligns with a growing educational trend toward blending modern scientific instruction with traditional pedagogies to foster relevance, inclusivity, and engagement. The analysis of *Tarik Tambang* and *Balap Karung* thus exemplifies how integrating local culture into science education can create transformative learning environments that nurture both scientific literacy and cultural identity.

CONCLUSION

Traditional games such as *Tarik Tambang* and *Balap Karung* not only carry significant cultural value but also embody fundamental physics concepts that can be explored through an ethnophysical approach. This study has demonstrated that *Tarik Tambang* exemplifies Newton's Second Law, where the acceleration of the opposing team depends on the net pulling force and the total system mass. The role of static friction is also crucial in maintaining players' balance during force application. Moreover, strategic player positioning—such as placing heavier individuals at the rear—enhances pulling effectiveness, as a larger differential force leads to faster displacement of the opposing team across the boundary line.

In *Balap Karung*, Newton's Third Law is clearly manifested in the interaction between the participants' feet and the ground. Each jump results from an action force applied backward, met with an equal and opposite reaction force propelling the participant forward. The concept of momentum is central, as higher mass or speed increases a participant's difficulty in halting motion abruptly. Additionally, the friction between the sack and the ground significantly influences the participant's stability and speed. Low friction can lead to slipping, whereas excessive friction slows forward progression. Thus, the game demonstrates the complex interplay between propulsion force, acceleration, momentum, and friction in determining movement efficiency.

Through this analysis, the study affirms the educational potential of traditional games as effective, contextual tools for teaching physics. By recognizing the application of physical laws in daily cultural practices, students can more easily relate abstract theories to tangible experiences. Therefore, the findings of this study are expected to serve as a reference for educators in developing culturally responsive teaching methods that not only enhance comprehension but also celebrate and preserve local traditions.

RECOMMENDATION

Based on the findings of this study, it is recommended that physics teachers continue to develop and utilize traditional games such as *Tarik Tambang* and *Balap Karung* as contextual and engaging learning media. These games not only enhance student interest and participation but also facilitate a more concrete understanding of physics concepts through real-life applications. By incorporating such culturally relevant activities, teachers can create a more meaningful and interactive classroom environment.

For future improvement, it is advisable that educators consider modifying or adapting the games to better align with specific learning indicators. Adjustments may include refining the rules or structure of the games to emphasize particular physics concepts, while also ensuring effective time management and prioritizing student safety during implementation. Proper planning will help maximize the educational value of the activities without compromising instructional efficiency or learner well-being.

Additionally, it is important to conduct regular evaluations to assess the effectiveness of these traditional game-based learning strategies. Continuous assessment will provide insights into their impact on students' learning outcomes and help identify areas that require refinement. Such evaluations are essential for ensuring that these culturally enriched instructional approaches remain relevant, effective, and responsive to educational goals.

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