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Analysis of the Concepts of Kinetic Energy , Potential Energy, and Free Fall Motion in Work and Energy Materials with the Help of *a Video Tracker*

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ABSTRACT

Physics concepts can be analyzed using several learning applications, one of which is *a video tracker* . The purpose of this study is to analyze the concept of kinetic energy, potential energy, and free fall motion using *a video tracker* . The method used in this study is an experimental method with 2 types of balls that have mass and are positioned at different heights. Data analysis uses quantitative descriptive by comparing data obtained from the analysis of *video tracker experiments* and direct experiments. The results of this study indicate that the experimental data from *the video tracker* and direct experiments obtained almost the same and very far differences in several concepts of kinetic energy and potential energy. This is due to the use of low-quality *cellphone cameras, the inability of the video tracker* to detect the results of several components (height, kinetic energy, and time), and the neglect of air resistance in *the video tracker* . So that *the video tracker* is less accurate in analyzing the physics concepts of kinetic energy, potential energy, and free fall motion.

Keywords: kinetic energy; potential energy; free fall motion; *video tracker*

INTRODUCTION

Learning is an effort carried out by educators sequentially until effective and efficient teaching and learning activities occur with a planning, implementation, and evaluation flow [1] . One of the subjects in secondary schools is physics learning. Physics is a subject that discusses natural phenomena that can be solved by utilizing formulas, theories, equations, and concepts to prove the phenomena that occur. Thus, physics learning can be defined as part of a lesson that discusses natural sciences. Physics learning is also included in science learning which contains science flows, such as processes, scientific behavior, and *output* . Students who take physics learning should be able to relate directly to real things [2] . In physics learning, educators will convey things about formulas, theories, principles, concepts, convey the relationship between physics and examples in everyday life, and carry out practical activities in the laboratory [2] . Therefore, the characteristic of scientific physics learning is conducting experiments in order to achieve meaningfulness and interrelationships between mechanisms that prioritize behavior and output [1] . One of the materials in the physics subject is energy [3] .

Energy can cause the environment or objects to change. Changes in energy are carried out in various ways. Energy undergoes changes that come from one form to another form of energy. So, energy is an ability to do work [4] . The types of energy are divided into three, namely mechanical energy , kinetic energy, and potential energy. Mechanical energy is the sum of potential energy and kinetic energy [5] . Kinetic energy is energy possessed by an object due to its movement. The kinetic energy of an

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object is the effort required to move an object that has a certain mass with an initial condition of rest until it reaches a certain speed (Permana et al., 2022) . Potential energy is energy stored in an object due to the position or position of the object [7] .

Based on the above understanding, we can see that potential energy is influenced by the position of an object or position. In addition, potential energy is also influenced by the earth's gravitational force. Mathematically, potential energy can be written as Ep = mgh [8] . The application of potential energy in everyday life is in trampoline games [9] , balls falling from a height [10] , [11] , and so on. Potential energy can be analyzed using the *Tracker Video application* .

While the size of the kinetic energy is indicated by the force given which is interpreted in terms of speed. Kinetic energy is also influenced by mass. [8] . The faster the object moves, the greater the kinetic energy, which is formulated mathematically. $E_k = \frac{1}{2}mv^2$.Increasing kinetic energy will require particle effort and a certain speed, and the greater the mass of the object, the greater the kinetic energy produced. [12] .

Free fall is the motion of an object falling in a vertical direction from a certain height without initial velocity. [13] . Based on theory, free fall motion is influenced by the Earth's gravitational force. [14] . Galileo stated that for free fall motion, all objects will fall with the same acceleration if there is no air or other resistance. [15] . The acceleration of an object is caused by the gravitational force which is 9.83m/s ^{2} . The acceleration due to gravity does not depend on the properties of the material. In the equatorial region the value of g = 9.78 m/s ^{2} while in the polar region it is 9.83m/s ^{2} [16] .

Tracker video is used to model and analyze videos designed for physics learning [17] . *Tracker* is a *software* that has a function to analyze an object recorded on a video about natural events related to speed, velocity, acceleration, force, gravitational field, conversion and conservation [18] . This tracker device is supported by digital resources that combine videos and tutorials that can be analyzed. So it can be interpreted that the tracker is a software used to analyze video of an object's motion.

software has several benefits, namely overcoming the limitations of laboratory practical tools. The advantages of *the video tracker* are that it is able to present real physical phenomena along with their representations in the form of quantitative data and graphs [19] , can present many ways of presenting data [20] , helps in learning physics [21] , and makes physics learning relevant to the real world [22] .

Based on the description of the material above, it is necessary to conduct this research with the aim of analyzing the comparison of potential energy results between manual calculations using formulas and the results on *the video tracker* .

RESEARCH METHODS

The research method used is the experimental method. The experimental method is a trial method used to prove an existing theory. The experimental method is included in the type of quantitative research method. This type of research is conducted to see the effect of independent variables on dependent variables [23] . The experiment that the researcher conducted was to drop 2 types of balls with different masses at different heights, then analyze the kinetic energy, potential energy, and free fall motion using the *Tracker Video application* . The independent variables in this study are the height and mass of the ball. While the dependent variables in this study are kinetic energy, potential energy, and free fall motion energy.

RESULTS AND DISCUSSION

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Table 1 Experimental Result Data Using Video Tracker with Basketball Object

y	h (m)	Ek (J)	t (s)
y_3	1,699	0	0.05
y_2	0.848	5,561	0.45
y_1	0.073	664.2	0.63

Table 2 Direct Experimental Result Data with Basketball Objects

y	h (m)
y_3	1.7
y_2	0.85
y_1	0

Based on the two tables above, it can be seen that when conducting an experiment directly measuring the height of a basketball with a mass of 0.555 kg, namely 1.7 meters (y_3), it can be seen that half of 1.7 meters is 0.85 meters (y_2) and the lowest height is 0 meters (y_1). However, what is read on *the video tracker* is 1.699 meters (y_3), 0.848 meters (y_2) as the middle height and 0.073 meters (y_1) as the lowest height. This difference is what causes the results of *the video tracker* and manual calculations on the concept of physics to differ. Based on the data in the table above, the potential energy obtained when y_3 from the experiment using *the video tracker* is as follows:

$$Ep_{TV} = m \times g \times h \quad (1)$$

$$Ep_{TV} = 0{,}555 \times 9{,}8 \times 1{,}699$$

$$Ep_{TV} = 9{,}240\ Joule$$

Meanwhile, the potential energy obtained when y_3 from direct experiments is as follows:

$$Ep_L = m \times g \times h \quad (2)$$

$$Ep_L = 0{,}555 \times 9{,}8 \times 1{,}7$$

$$Ep_L = 9{,}246\ Joule$$

Based on the data above, the results of experiments using *video trackers* and directly obtained almost the same results.

In addition, the data above states that if the potential energy at y_3 (highest) is worth 9,240 Joules, then the kinetic energy is worth 0 Joules. Meanwhile, if the potential energy obtained at y_1 (lowest) is worth 0 Joules, then the kinetic energy is worth 664.2 Joules. Based on these data, it is obtained that potential energy is inversely proportional to kinetic energy. Several concepts state that the value of potential energy will be the same as kinetic energy when it is at the midpoint of the height (y_2). The following is proof of potential energy and kinetic energy when y_2:

$$Ep_2 = Ek_2 \quad (3)$$

$$m \times g \times h \,?\, 5{,}561\ Joule$$

$$0{,}555 \times 9{,}8 \times 0{,}848 \,?\, 5{,}561\ Joule$$

$$4{,}612\ Joule \neq 5{,}561\ Joule$$

Based on the proof of the results above, almost the same results were obtained for potential energy and kinetic energy when y_2.

The above data can also prove that the height obtained is in accordance with the experimental data using *a video tracker*. The researcher took data at y_3, then the following results were obtained:

$$h = \frac{1}{2} \times g \times t^2 \quad (4)$$

$$y_3 = \frac{1}{2} \times g \times t^2$$

$$1{,}699\ meter \,?\, \frac{1}{2} \times 9{,}8 \times 0{,}05^2$$

$$1{,}699\ meter \neq 0{,}012\ meter$$

Based on the above evidence, the results

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obtained are not the same. However, the relationship between time and kinetic energy is directly proportional, while the relationship between time and height and potential energy is inversely proportional.

Table 3 Experimental Result Data Using Video Tracker with Volleyball Object

y	h (m)	Ek (J)	t (s)
y_3	1,433	0	0.567
y_2	0, 723	6,721	0.4
y_1	0.087	392.1	0.017

Table 4 Direct Experimental Result Data with Volleyball Objects

y	h (m)
y_3	1.5
y_2	0.75
y_1	0

Based on the two tables above, it can be seen that when conducting an experiment directly measuring the height of a volleyball with a mass of 0.269 kg, namely 1.5 meters (y_3), it can be seen that half of 1.5 meters is 0.75 meters (y_2) and the lowest height is 0 meters (y_1). However, what is read on *the video tracker* is 1.433 meters (y_3), 0.723 meters (y_2) as the middle height and 0.087 meters (y_1) as the lowest height. This difference causes the results of *the video tracker* and manual calculations on the concept of physics to differ. Based on the data in the table above, the potential energy obtained when y_3 from the experiment using *the video tracker* is as follows:

$$Ep_{TV} = m \times g \times h$$

$$Ep_{TV} = 0{,}269 \times 9{,}8 \times 1{,}433$$

$$Ep_{TV} = 3{,}77 \ Joule$$

Meanwhile, the potential energy obtained when y_3 from direct experiments is as follows:

$$Ep_L = m \times g \times h$$

$$Ep_L = 0{,}269 \times 9{,}8 \times 1{,}5$$

$$Ep_L = 3{,}95 \ Joule$$

Based on the data above, the results of experiments using *video trackers* and directly obtained almost the same results.

In addition, the data above states that if the potential energy at y_3 (highest) is worth 3.77 Joules, then the kinetic energy is worth 0 Joules. Meanwhile, if the potential energy obtained at y_1 (lowest) is worth 0 Joules, then the kinetic energy is worth 392.1 Joules. Based on these data, it is obtained that potential energy is inversely proportional to kinetic energy. Several concepts state that the value of potential energy will be the same as kinetic energy when it is at the midpoint of the height (y_2). The following is proof of potential energy and kinetic energy when y_2:

$$Ep_2 = Ek_2$$

$$m \times g \times h \ ? \ 6{,}721 \ Joule$$

$$0{,}269 \times 9{,}8 \times 0{,}723 \ ? \ 6{,}721 \ Joule$$

$$1{,}905 \ Joule \neq 6{,}721 \ Joule$$

Based on the proof of the results above, the results obtained are not the same for potential energy and kinetic energy when y_2.

The above data can also prove that the height obtained is in accordance with the experimental data using *a video tracker*. The researcher took the data at y_3, then the following results were obtained:

$$h = \frac{1}{2} \times g \times t^2$$

$$y_3 = \frac{1}{2} \times g \times t^2$$

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$$1{,}433\ meter\ ?\ \frac{1}{2} \times 9{,}8 \times 0{,}567^2$$

$$1{,}433\ meter \neq 1{,}575\ meter$$

Based on the proof above, almost the same results are obtained. However, the relationship between time and kinetic energy is directly proportional, while the relationship between time and height and potential energy is inversely proportional.

The effect of mass and height on kinetic energy is inversely proportional, while the relationship between mass and height with potential energy and free fall motion is directly proportional. This is proven by the following results when y $_2$:

When $m_{voli} = 0{,}269\ kg$, then obtained

$$E_k = 6{,}721\ Joule, E_p = 1{,}905\ J, GJB = 0{,}784\ m$$

When $m_{basket} = 0{,}555\ kg$, then obtained

$$E_k = 5{,}561\ Joule, E_p = 4{,}612\ J, GJB = 0{,}992\ m$$

So it can be concluded that the difference in results is caused by the video being taken using a low-quality *cellphone camera, the inability of the video tracker* to detect the results of several components (height, kinetic energy, and time), and the neglect of air resistance on *the video tracker* .

CONCLUSION

Based on the experiment with a basketball object, almost the same results were obtained in determining potential energy using video tracker data with direct experiments at y $_3$ and determining potential energy and kinetic energy at y $_2$ using *a video tracker.* While the experiment using a volleyball obtained almost the same results in determining potential energy using video tracker data with direct experiments at y $_3$ and determining free fall motion at y $_3$ using *a video tracker.* However, the experiment using a basketball obtained different results in free fall motion at y $_3$ using *a video tracker.* This is due to using a low-quality *cellphone* camera , the inability *of the video tracker* to detect the results of several components (height, kinetic energy, and time), and ignoring air resistance on *the video tracker* , so that *the video tracker* is less accurate in analyzing the physics concepts of kinetic energy, potential energy, and free fall motion.

BIBLIOGRAPHY

[1] CE Erlinawati, S. Bektiarso, and Maryani, "Project Based Learning Model Based on STEM in Physics Learning," *Semin. Nas. Pendidik. Phys.* , vol. 4, no. 1, pp. 1–4, 2019.

[2] A. Permata and YB Bhakti, "The Effectiveness of Virtual Class with Google Classroom in Physics Learning During the Covid-19 Pandemic," *JIPFRI (Jurnal Inov. Pendidik. Fis. dan Ris. Ilmiah)* , vol. 4, no. 1, pp. 27–33, 2020, doi: 10.30599/jipfri.v4i1.669.

[3] GY Saputra, A. Harjanto, and YA Ningsih, "Development of Android-Based Learning Media for Physics Subjects with Energy Topic in Class X IPA 1 of SMA Negeri 2 Muara Badak in the 2019/2020 Academic Year," *J. Adv. Inf. Ind. Technol.* , vol. 2, no. 2, pp. 10–24, 2020, doi: 10.52435/jaiit.v2i2.67.

[4] A. Kadir and Zainuddin, *Basic Physics Integrated with Quranic Values* . Yogyakarta: Bentang Pustaka, 2021.

[5] RE Zafitri, S. Fitriyanto, and F. Yahya, "Development of Diagnostic Test for Misconceptions on Work and Energy Material Based on Adobe Flash for Class XI at MA NW Samawa Sumbawa Besar in the 2017/2018 Academic Year," *J. Education* , vol. 2, no. 2, pp.

ISSN: 2502-2318 (Online)
ISSN: 2443-2911 (Print)

Homepage :
https://journal.uhamka.ac.id/index.php/omega

19–34, 2018.

[6] KL Permana, F. Hasyim2, and Trise Nurul Ain, "The concept of work and energy: integration of the Qur'an in physics learning," *Seminar. Nas. Education, FKIP UNMA* , pp. 360–368, 2022.

[7] A. Majid *et al.* , "Utilization of Water Pumps as Prime Over," vol. 3, no. 2, pp. 262–268, 2019.

[8] R. Rumiati, RD Handayani, and IK Mahardika, "Analysis of the Physics Concept of Mechanical Energy in Traditional Stilt Games as Physics Learning Materials," *J. Educ. Phys.* , vol. 9, no. 2, p. 131, 2021, doi: 10.24127/jpf.v9i2.3570.

[9] VS Biyan and W. Setyarsih, "Validity of Critical Thinking Skills Assessment Instrument Through Formal Reasoning in Problem Solving on Effort and Energy Material," *IPF Inov. Educator. Phys.* , vol. 9, no. 3, pp. 447–458, 2020, doi: 10.26740/ipf.v9n3.p447-458.

[10] MF Nurfauzan, S. Santi, SN Rahmawati, and MG Sari, "Instantaneous Velocity Test Through Parabolic Motion Using Tracker Software on Frictional Surface," *J. Teach. Learn. Phys.* , vol. 3, no. 1, pp. 11–17, 2018, doi: 10.15575/jotalp.v3i1.6546.

[11] RRH Hau and Sumarli, "Identification of the Application of Learning Theory in Physics Learning," *J. Educ. Phys. and Sci.* , vol. 3, no. 1, pp. 1–8, 2021.

[12] B. Kalhor, F. Mehrparvar, and B. Kalhor, *Does Using MultiDimentional Energy-Momentum Equation Change The Kinetic Energy formula* . Iran: Independent Researcher Form alborz, 2020.

[13] G. Dauglas C, *Physics Volume 2.* Jakarta: Erlangga, 2001.

[14] OA Atani, LAS Lapono, and AC Louk, "Design and Construction of Free Fall Motion Experiment Demonstration Equipment," *J. Phys. Phys. Sci. and Appl.* , vol. 4, no. 1, pp. 33–39, 2019 , doi: 10.35508/fisa.v4i1.1435.

[15] Z. Ngara, *Basic Physics volume 1.* Kupang: Udana Press, 2008.

[16] HD Young, RA Freedman, T. . Sandin, and A. Ford, *University Physics* . Jakarta: Erlangga, 2002.

[17] I. Fitriyanto and I. Sucahyo, "Application of Tracker Video Analyzer Software in Motion Kinematics Practicum," *J. Inov. Educ. Phys.* , vol. 05, no. 03, pp. 92–97, 2016, [Online]. Available: https://doi.org/10.26740/ipf.v5n3.p%25p.

[18] DR Setyaningsih and NMD Putra, "Unnes Physics Education Journal," no. 2, 2021.

[19] and SRA Khotijah, Arsini, "Development of Physics Practical Work on the Law of Conservation of Momentum Using the Video Tracker Application," vol. 1, no. 1, pp. 37–45, 2019.

[20] Anissofira and PS, A, FDE Latief, L Kholida, "Newton's Cradle Experiment Using Video Tracking Analysis with Multiple Representation Approach Newton's Cradle Experiment Using Video Tracking Analysis with Multiple Representation Approach," 2017.

[21] D. Asrizal, Yohandri and Z. Kamus, "Study of the Results of Video Analysis Training and Tracker Modeling Tools for MGMP Physics Teachers in Agam Regency," vol. 2, 2018.

[22] L. Kang Wee and T. Kwang Leong, "Video Analysis and Modeling Performance Task to Promote Becoming Like Scientists in Classrooms," *Am. J. Educ. Res.* , vol. 3, no. 2, pp. 197–207, 2015, doi: 10.12691/education-3-2-13.

[23] S. Rachmawati, AZ Ibrahim, SP Fajriani, and I. Febilioni, "Study of Free Fall Motion with Lagrangian & Newtonian Equations as Physics Teaching Material for Class X," *Mitra Pilar J. Education, Innovation, and Application. Teknol.* , vol. 1, no. 2, pp. 141–154, 2022, doi: 10.58797/pilar.0102.07.