ANALYSIS OF VERTICAL MOVEMENTS ON FREEDOM AND BULLET MOVEMENT EVENTS USING VIDEO TRACKING METHOD

Lusia Koja Kanga[1], Richardo Barry Astro[2], Yasinta Embu Ika[3]
[123)] Faculty of Teacher Training and Education University of Flores
e-mail: lusiakojakanga@gmail.com

Abstract

Analysis of vertical motion in free fall and bullet motion with the video tracking method has been carried out. This study aims to analyze the vertical motion pattern in the free fall and bullet motion, specifically the ball launching from the edge of the table. The research was carried out by rolling the ball until it slid and releasing the ball from the edge of the table until it experienced a free fall motion with the height of the table from the two activities of about 1 meter. This activity was carried out repeatedly until obtaining 5 videos of each event and recorded using the Vivo android camera. Furthermore, researchers analyzed using the Tracker application to obtain information data about vertical motion patterns, graphs of changes in position with time, and graphs of velocity against time. Result of regressive analysis can derive equations $v_y = A^x + B$ *and* $y = A^x + B$

Keywords: *Bullet motion, Free fall motion, Vertical motion, Video tracking*

1. INTRODUCTION

Motion kinematics has been studied at the secondary education level, but often the presentation of learning is only theoretical and not contextual, and without adequate practicum to be able to improve science process skills. Several motion events such as vertical motion can be shown and analyzed with the help of video tracking technology (Supriyadi, 2008).

An object is said to experience free fall motion, if the object is released from a certain height to the ground without initial velocity. Objects that are dropped from above will fall to the earth because the object is accelerated due to gravity (g) which is always towards the center of the earth (Agung Ristiawan1, 2018). "A scientist, Galileo (1564-1642) opened a new perspective on the importance of experimenting. Galileo conducted experiments on free-falling objects, including measuring objects falling on the tower of Pisa. The experimental results show that the time it takes for objects to fall does not depend on their mass but depends on their the height "(Sri Handayani, nd).

"Free fall motion is a natural phenomenon studied in physics. "(1) Lukman Fadholi, 1) Alex Harijanto, 2018). Free fall motion is the motion of an object in the vertical direction which is dropped from a certain height (Obet A. Atani, Laura AS Lapono, 2019). Free fall motion is the motion of an object caused by the pull of the earth and without any other force acting on it (Adnan, 2009). This free fall motion has a condition, namely initial velocity $(v_0) = 0$. In free fall this also applies to relationships $v = g.t$ and $s = \frac{1}{2}.g.t^2$ and g is the gravitational acceleration of the earth. So in this motion, objects are only affected by the Earth's gravitational acceleration.

Pantur (1985: 61) states that free fall motion is a motion capable of reacting an object in a straight path due to the influence of the earth's gravity. Free fall motion is motion that ignores friction and small changes in acceleration with respect to height. The acceleration experienced by a free falling object is caused by gravity which is 9.8 m / s2 or 980 cm / s2 which points to the center of the earth. The friction referred to here is the friction between the object and the air. An object dropped from a certain height in an open space will be slowed down due to the friction force with the air velocity. Sutrisno (1986: 78) states that an object is said to be in free fall if it is moving without its initial

velocity $(v_0 = 0)$ and is not influenced by the thrust but is influenced by the earth's gravitational force. Free fall motion is included in accelerated straight motion (GLBB). The acceleration experienced by this object is a result of the earth's gravitational pull. Since the condition for free fall motion is that the initial acceleration is zero, the GLBB equation is as follows:

$$V_t = v_0 = a.t$$
$$V_t^2 = v_0 + 2a.s$$
$$S = v_0.t + \frac{1}{2}a.t^2$$

Because in the free fall motion the initial velocity $(v_0 = 0)$ and the acceleration experienced by the object is the acceleration due to gravity, then the formula applies:

$$V = a.t$$
$$V_t^2 = 2as$$
$$S = \frac{1}{2}a.t^2$$

Abdullah (2012) The above event in physics is referred to as free fall, which is a straight motion changing regularly on a vertical trajectory. Its characteristic feature is that the object falls without its initial velocity (vo = zero). The lower the object, the faster it is.

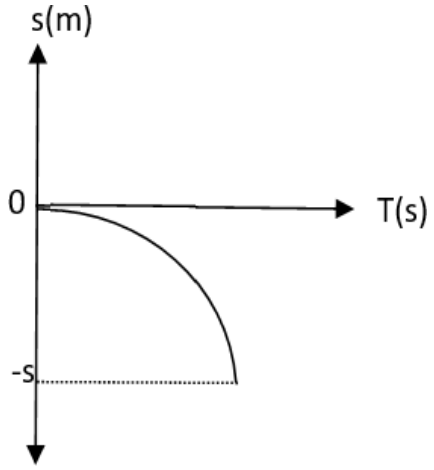

Figure 1. Graph of free fall motion

"Parabolic motion is a topic that is used in learning kinematics, namely the combination of motion in the direction of the X axis and the Y axis"(Ishafit2), 2014). "Parabolic motion is the two-dimensional motion of a bullet that is thrown at an upward angle"(Farah Sarjani, Yohandri, 2017). "In parabolic motion, if the air resistance and the effects of the earth's rotation are ignored, and the gravitational acceleration is considered constant, then the component of the force that works is only the earth's gravitational force experienced by the object or it is called the object's gravity. In this case, the object's weight is constant, both in magnitude and direction. (Supardi, 2011) "(Muhamad Fasha Nurfauzan, Santi, Sarah Nur Rahmawati, 2018).

"The motion of a bullet is the motion of an object whose trajectory is a parabola. Parabolic motion is a type of motion of an object which is initially given an initial velocity and then travels a path whose direction is fully influenced by gravity so that the path is parabolic "(1) Lukman Fadholi, 1) Alex Harijanto, 2018). This kind of motion can be found in bullets, for example the event of an object with horizontal velocity falling from the edge of the table, other examples in everyday life such as the movement of a tennis ball when it bounces due to a push from a tennis racket, a bomb dropped from an airplane and an object thrown from it. ravine. The direction is vertical downward and constant. In a bullet, the vertical acceleration is affected by the acceleration due to gravity. The force of gravity on the bullet towards the center of the earth and inversely proportional to the square of the distance from the center of the earth. "Parabolic motion is composed of a component of motion in the vertical direction (y axis) and a component of motion in the horizontal direction (x axis)"(Disah Nur Afifah *, Dewi Yulianawati, Nina Agustina, Ratu Dewi Sri Lestari, 2015).

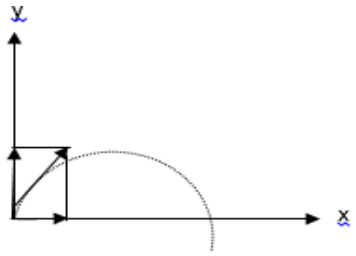

Figure 2.Graph of the components of the parabola motion

$$v_t = v_0 + gt$$

$$y_t = y_0 + v_{0,y}\, t + \frac{1}{2} gt^2$$

$$v_t^2 = v_0{}^2 + 2g\Delta y$$

Information:

v_t = velocity of an object at any given time (m/s)

v_0 = the initial velocity of the object $(m/s) = 0$

$t = waktu$ (second)

"Parabolic motion applies to the motion of objects if: the earth is homogeneous, the height of the object is fixed, the air pressure is small or the object moves slowly, and there is a north pole or south pole (Putu Artawan, 2014)"(Juniastel Rajagukguk1 *, 2017).

"The most appropriate topics for Tracker software are those related to kinematics and phenomena of motion in general (Habibbullah and Madlazim, 2014). Tracker software has a calibration facility, so the measurement results obtained will be very close to reality(Ristanto, 2012). This proves that tracker software is very good for analyzing videos of physics events. "(1) Lukman Fadholi, 1) Alex Harijanto, 2018). "Tracker can analyze natural events especially those related to speed, speed, acceleration, force, gravitational field, energy conversion and conservation"(Muhammad Habibbulloh, 2014). "By using the Tracker, it is possible for students to be brought directly into a real world model based on Newton's laws."(Almira Anissofira1, a), Fourier Dzar Eljabbar Latief2, b), and Parlindungan Sinaga3, 2016).

"Tracker is a video analysis application formed in the field of physics with the java framework type (Brown, 2009; Wee, 2015). Tracker software can be downloaded easily and can be used on computers (Firdaus, 2017). Tracker is an excellent application for combining video and computer. The videos analyzed using this software are supported by digital resources (Gregorio, 2015). From these three definitions, it can be concluded that the tracker is a software capable of analyzing a video of the motion of an object. This tracker is designed to be applied in physics learning and can be used easily (Repnik, 2015). Tracker provides an appropriate video analysis software as a support for delivering physics concepts in a lesson. The uniqueness of the tracker is that it can visualize physics concepts in real time (Eddy, 2016). Learning that is applied with video tracker analysis is an appropriate contribution in developing and increasing student creativity in learning physics. This method can be used as an alternative to experimental activities in a laboratory. Trackers provide many ways for users to represent data. Tracker software provides tools for the representation of multiple experimental data. Video tracking analysis using tracker software is also able to practice many representation skills in the context of physics (Anissofira, 2017). " Learning that is applied with video tracker analysis is an appropriate contribution in developing and increasing student creativity in learning physics. This method can be used as an alternative to experimental activities in a laboratory. Trackers provide many ways for users to represent data. Tracker software provides tools for the representation of multiple experimental data. Video tracking analysis using tracker software is also able to practice many representation skills in the context of physics (Anissofira, 2017). " Learning that is applied with video tracker analysis is an appropriate contribution in developing and increasing student creativity in learning physics. This method can be used as an alternative to experimental activities in a laboratory. Trackers provide many ways for users to represent data. Tracker software provides tools for the representation of multiple experimental data. Video tracking analysis using tracker software is also able to

practice many representation skills in the context of physics (Anissofira, 2017). "(Asrizal1), Yohandri2), 2018).

"There are two basic types of practical tracker models: (1) analysis and (2) dynamic. Dynamic particle models in turn may be Cartesian, polar or systems of two bodies subject to internal and external forces. All models built using the Tracker "Model Builder", provide controls for defining and various parameters, initial conditions, and positions or style expressions. "(Wijayanto, 2015). "There are several steps that need to be considered when using the tracker, as follows: 1) installing the tracker application, 2) running the tracker application. Tracker can be run if the PC used is supported by Java. 3) open the motion video to be analyzed. 4) perform the calibration. 5) create Cartesian coordinates. 6) track the movement of objects. With the motion tracker, the graphs can be observed, whether it is a graph of displacement against time, distance to time, velocity against time, acceleration against time and so on "(Wijayanto, 2015). "By using tracker software, measurement of object motion parameters can be done more accurately and more accurately"(Muhamad Fasha Nurfauzan, Santi, Sarah Nur Rahmawati, 2018).

2. RESEARCH METHODS

The research used was to analyze the vertical motion pattern in the free fall and bullet motion, specifically the ball launching from the edge of the table using the Tracker application. This research was conducted at the researcher's house, Jln. Sam Ratulangi Ende.

The tools and materials used in this experiment are: baseball as the object being observed, a table as high as 1 m, a VIVO android camera and a tripod, a laptop with a Tracker application installed, a 30 cm ruler.

The research procedures are as follows:

1. Movement of bullets (launching the ball from the edge of the table)
   a) Measure the height of the table
   b) Place the ball on the table and roll it so that it slides off the edge of the table
   c) Record the activity with the camera statically attached to the support
   d) Take repeated measurements so that valid data is obtained
   e) Video analysis uses Tracker to obtain vertical motion patterns that occur.

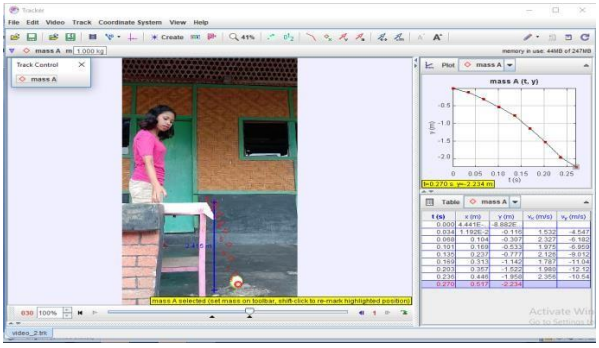

Figure 3. Graph of vertical position with respect to time (yt)

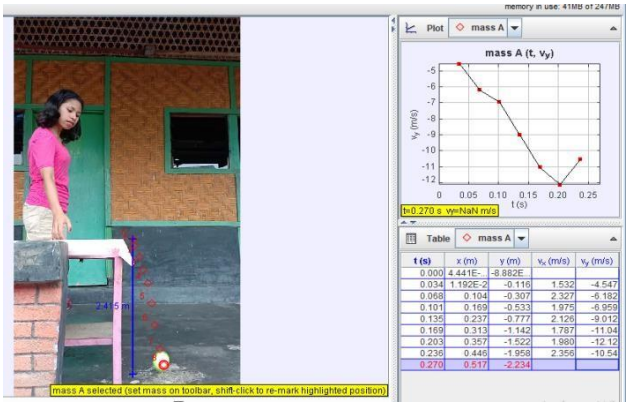

Figure 4. Graph of vertical velocity against time ($V_{y-}t$)

2. Free fall motion
   a) Place the ball at the same height as the table
   b) Release the ball until it is in free fall.
   c) Record the activity with the camera statically attached to the support
   d) Take repeated measurements so that valid data is obtained

Video analysis uses Tracker to obtain vertical motion patterns that occur.

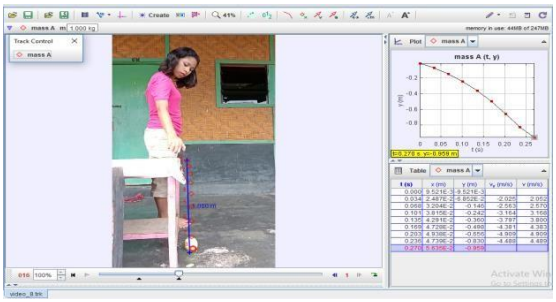

Figure 5. Graph of vertical position against time (yt)

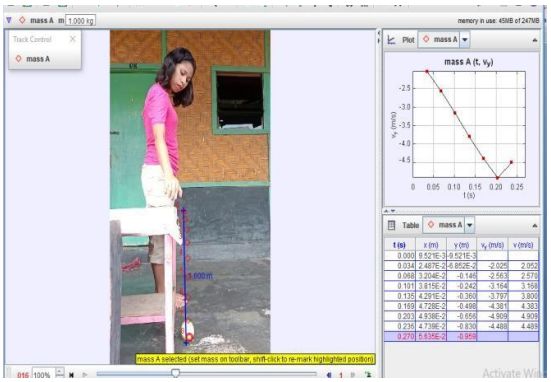

Figure 6. Graph of vertical velocity of free fall with respect to time (vy-t)

3. RESULTS AND DISCUSSION

Result of vertical motion pattern at gebullet rack as in figures 3 and 4.

Picture 1 is a graph of the change in vertical position on the y-axis, proportional to the change in time.In this graph, the motion on the y-axis is a straight, regular motion because the influence of the earth's gravitational force does not exist so that the velocity on the y-axis is constant. Figure 4 is a graph of vertical velocity against time ($V_{y-}t$), in this graph, the motion on the y-axis is a straight motion changing regularly because the earth's gravitational force causes the object to change its velocity.

The results of the vertical motion pattern in free fall motion are as shown in Figures 5 and 6.To obtain data analysis between one variable and another, select Analyze and in the fit name select Line so that the vertical velocity equation in free fall motion and bullet motion of each graph can be obtained by the equation: Vy = Axt + B and the equation of vertical position with respect to time can be obtained by the equation: y = Axt + B.

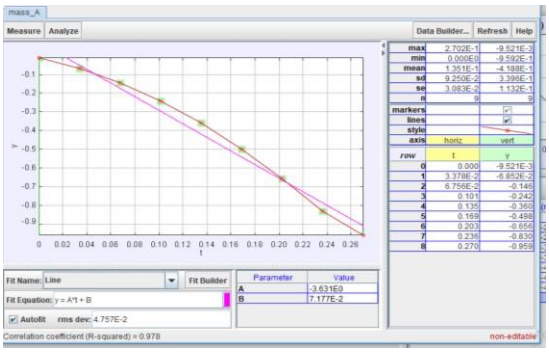

Figure 7. Hresult of vertical motion regressive data analysis on bullet motion

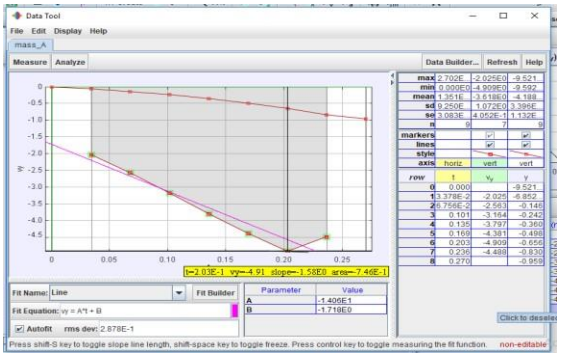

Figure 8. Hresult of vertical motion regressive data analysis on bullet motion

From these pictures are taken from one of the regressive data analysis results of vertical motion in free fall and bullet motion for all videos analyzed. Figure 7 is the regressive result of one of the free fall motion and Figure 8 is the regressive result of the motion of the bullet.

Videotracker analysis can show the closeness of the measurement results to the actual value. It should be noted that in using the tracker, the practical tool to be used must be well prepared and in the process of recording the video you must also pay attention to the quality of the camera because the quality of the camera greatly affects the results of the recording and tracker analysis (Vinka Raflesiana, Kartini Herlina, 2019; Toda, S. et al, 2020; Silvia, T., et al, 2020).

4. CONCLUSION

Result regressive analysis obtained equations $v = \underset{y}{=} A^x + B$ and $y = A^x + B$. In analyzing the vertical motion pattern in the free fall and bullet motion, especially the ball launching from the edge of the table with the Video tracking method, it can be seen that the motion pattern is quite appropriate so that the Video Tracking method can be applied in the field of education.

In interpreting graphics, you can use video tracker analysis on learning physics, especially on motion material. Video analysis using the tracker method is capable of processing data to get graphs, tables, and equations of motion.

5. REFERENCE

Fadholi, L., Harijanto, A., & Lesmono, A. D. (2018). Video Analysis of Physical Events Using Software Tracker as A Design of Momentum and Impuls Teaching Materials to Improve The Critical Thinking Ability Of Class X 1 High School Students. *Journal of Learning Physics*, *7*(3), 263–270.

Ristiawan, A. (2018). FALL FREE MOTION ANALYSIS USING THE VIDEO BASED LABORATORY (VBL) METHOD USING SOFTWARE TRACKER. Journal of Teaching and Learning Physics, 3 (2), 26–30. https://doi.org/10.15575/jotalp.v3i2.6556

Almira Anissofira1, a), Fourier Dzar Eljabbar Latief2, b), and Parlindungan Sinaga3, C. (2016). PROSIDING SKF 2016 Analysis of Roller Coaster Motion Using a Tracker with a Multi Mode Representation Approach as a Means for Students to Understand the Concept of Kinematics. 26–32.

Asrizal1), Yohandri2), ZK (2018). Study on the Results of Training on Video Analysis and Tracker Modeling Tool for Physics MGMP Teachers in Agam Asrizal 1), Yohandri2) ,. Journal of Educational Exact (Jep), 2 (1), 41. https://doi.org/10.24036/jep/vol2-iss1/84

Disah Nur Afifah *, Dewi Yulianawati, Nina Agustina, Ratu Dewi Sri Lestari, MGN (2015). A Simple Method of Determining Earth's Gravitational Acceleration Using a Tracker Application in Parabolic Motion as a Media in High School Physics Learning. Proceedings of the 2015 National Symposium on Innovation and Science Learning (SNIPS 2015), 1 (Snips), 305–308.

Farah Sarjani, Yohandri, ZK (2017). Making Digital Parabolic Experiment Set Based on ATMega328 Microcontroller for Measuring Motion Parameters. Pillar of Physics, 10 (1), 23–30.

Ishafit2), P. and. (2014). Modeling of Parabolic Motion which is Affected by Drag and Spin of the Magnus Ball Effect with Modellus and Excell Programs. 1 (1), 11–18.

Juniastel Rajagukguk1 *, CS (2017). TWO DIMENSIONAL PARABOLIC MODELING AND ANALYSIS USING THE MATLAB Juniastel GUI APPLICATION. Saintika's Journal, 17, 63–68.

Muhamad Fasha Nurfauzan, Santi, Sarah Nur Rahmawati, MGS (2018). Instantaneous Speed Test Through Parabolic Motion Using Tracker Software On A Friction Surface. Journal of Teaching and Learning Physics, 3 (1), 11–17. https://doi.org/10.15575/jotalp.v3i1.6546

Muhammad Habibbulloh, M. (2014). Application of Video Tracker Software Analysis Method in Learning Physics Concept of Free Fall Motion to Improve Process Skills of Class X Sman 1 Students Sooko Mojokerto. Journal of Physics Education and Its Applications (JPFA), 4 (1), 15–22. https://doi.org/10.26740/jpfa.v4n1.p15-22

Obet A. Atani, Laura AS Lapono, ACL (2019). Design of Free Fall Movement Practicum Teaching Aid. Journal of Physics: Physics of Science and Its Applications, 4 (1), 33–39. https://doi.org/10.35508/fisa.v4i1.1435

Ristanto, S. (2012). FALL FREE

MOVEMENT EXPERIMENT BASED ON VIDEO RECORDING IN MA WAHID HASYIM. Journal of Learning Physics Research, 3 (9), 1–8. https://doi.org/10.1017/CBO9781107415324.004

Silvia Triana Juita, Seko, MS., Seku, AY., Ahmad, S.., & Astro, RB (2020). DETERMINATION OF OBJECT RESTITUTION COEFFICIENT USING VIDEO TRACKING METHOD. OPTIKA: Journal of Physics Education, 4 (1), 46-53. https://doi.org/10.37478/optika.v4i1.365

Sri Handayani, AD (nd). Physics for SMA and MA Class X.

Toda, S., Mala Tati, MY., Bhoga, YC., & Astro, RB. (2020). GRAVITY ACCELERATION DETERMINATION USING THE CONCEPT OF FALL FREE MOTION. OPTIKA: Journal of Physics Education, 4 (1), 30-37. https://doi.org/10.37478/optika.v4i1.367

Vinka Raflesiana, Kartini Herlina, IW (2019). THE EFFECT OF USE TRACKER ON SIMPLE HARMONIC MOVEMENT LEARNING BASED ON GUIDED INQUIRY ON STUDENT'S GRAPHIC INTERPRETATION SKILLS. Journal of Chemical Information and Modeling, 5 (9), 1–12. https://doi.org/10.1017/CBO9781107415324.004

Wijayanto, S. (2015). Motion Kinematics Design Using Air Track Experiment Tool for Video-Based Physics Learning Media. Upgris Journal of Informatics (JIU), 1 (2), 132–139. https://doi.org/http://dx.doi.org/10.26877/jiu.v1i2%20Desember.871