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Jumping Motion of Gourami Fish Using Tracker Software as a Mechanical Energy Conservation Practicum

Arina Zaida Ilma[1*], Heru Kuswanto[2], Adha Hujatulatif[1]

[1] Natural Science Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Daerah Istimewa Yogyakarta, Indonesia.

[2] Physics Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Daerah Istimewa Yogyakarta, Indonesia.

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Corresponding Author:
Arina Zaida Ilma
arinazaida.2021@student.uny.ac.id

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Abstract: One of the phenomena of gourami fish is the jumping motion. In analyzing the fish motion, errors are often experienced in observations, tend to be subjective or take a long time. An alternative software to analyze the fish motion is the Tracker software. The study aims to analyze the video of the Gourami fish motion phenomenon using Tracker software in the mechanical energy conservation practicum. This type of research is experimental research. Based on the results, the greater the mass of the fish indicates the greater the kinetic energy and potential energy in the motion of the fish. Kinetic energy depends on the mass and speed of the Gourami fish jumping. While the potential energy depends on the height of the Gourami fish when jumping. It is also affected by the fish's mass and the acceleration of gravity. The video analysis of the motion of the jumping gourami using Tracker can be used in science learning, especially in physics practicum about the law of conservation of mechanical energy.

Keywords: Gourami; Jumpion motion; Practicum; Tracker; Mechanical energy conservation

Introduction

National Science and Mathematics Standards have made clear that it is necessary to integrate technology in fields of study at all levels of education, including science. In fulfilling these demands, learning has sought to use technology with various models to investigate scientific phenomena in the real world. Investigation of types of motion with such detail and precision would be tight without technology (Bryan, 2004). Science is an approach to understanding natural phenomena by developing from our curiosity about ourselves, the planets, other life forms, and the universe (Campbell et al., 2018). In this universe, many animals can move, including fish. The mechanical movement of a swimming fish has been a topic of ongoing research (Eloy, 2012). Experiments involving animals have attracted the attention of almost all physiologists.

A stressed fish exhibits behaviors such as jumping, running away, swimming, or changing body color variations (Li et al., 2022). Jumping out of the water is a behavioral phenomenon of both aquatic (Gibb et al., 2013) and semi-aquatic animals (Chang et al., 2019). Many fish can jump out of the water and launch into the air. It is related to the activities of catching prey (Khosronejad et al., 2020; Shih et al., 2017), avoiding predators (Kim et al., 2015), and migrating (Soares & Bierman, 2013). This research focuses on practicum activities for learning science on the Gourami jumping motion. Similar experiments were on other animals, fish, and dogs (Klein, 2018), but no practical activity was to determine the conservation of motion energy of Gourami fish assisted by Tracker software. However, the research gap is to apply it to animal motion which can be found easily in life, especially in Gourami fish.

Animal motion is affected by several factors, namely disturbance from humans, foraging behavior, and topography in the modeling mechanism (Preisler et al., 2013). In this study, fish motion is affected by interference from humans to make Gourami fish move. Several studies have explained animal motion from a biological perspective (Baker et al., 2013), but few have

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studied physics in the scope of science. It is because analyzing the aquatic animals' motion is a process that takes a long time, and the subjective tendency, proneness to errors due to the fatigue factor of the researcher (Rachinas-Lopes et al., 2018). Therefore, investigating natural phenomena in the motion of aquatic animals becomes a tight thought, but it becomes easy using technology. Applications for automated and semi-automated video-based activities used to identify errors and biases in manual analysis, including Tracker software.

In physics learning, the famous Tracker is an easy-to-use open-source video analysis software designed by Douglas Brown (Claessens, 2017). A Tracker is an open-source software used for analysis and video modeling tools (Wee & Leong, 2015). By utilizing this software, a person can record a video using their cell phone and then analyze the motion of the object in the video (Nichols, 2019). The function of this Tracker software is to make it easier for students to investigate the center of mass and changes in position, speed, and acceleration with time. In addition, it can also visualize the concept of motion in real-time (Hockicko, 2011). The approach presented by using the Tracker software is interesting for teaching classical mechanics problems at various levels of science education (Claessens, 2017). A Tracker is used to identify phenomena in the real world and solve problems, namely parabolic motion, free fall motion, mechanical energy, and so on (Anissofira et al., 2016). Tracking methods allow for tracking the motion of different animals, such as fish (Pérez-Escudero et al., 2014), primates (Ballesta et al., 2014), mice (De Chaumont et al., 2012), and cats (Ramadhanti et al., 2021).

The use of the Tracker application in the learning and experimental tools is widespread, one of which is the use of Tracker software to determine mechanical energy. Fahrunnisa et al. (2021) investigated the law of conservation of mechanical energy using video trackers in learning physics in high school. The results showed that video analysis with the help of Tracker software helps experiential processes in learning mechanical energy. Bryan (2010) explained four of the most common situations in the conservation of mechanical energy of objects in free fall, simple pendulum motion, oscillating mass on a spring, and oblique rolling object. These phenomena investigate mechanical energy conservation from digital video analysis. Research on using video analysis as a learning method is needed, not limited to constructivism, direction, and direct instruction.

Method

In this study, the tools and materials used include an Android camera, Gourami fish, and a Tracker application. The measurement results are in the form of position data on the x-axis, position on the y-axis, kinetic energy, potential energy, and mechanical energy with Tracker software.

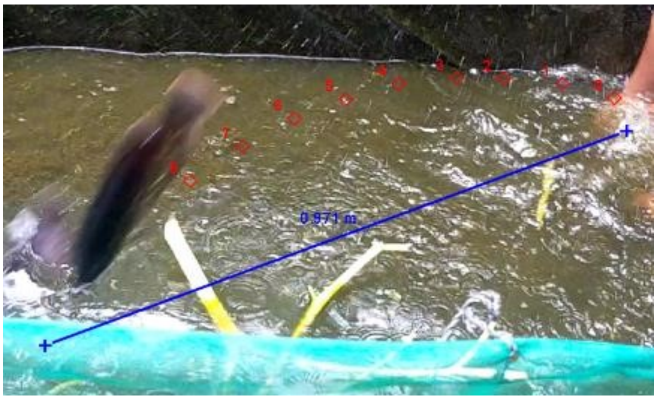
The first procedure of this research was to record the jumping motion of the Gourami using an android camera on each Gourami. After that, we analyzed the fish motion with the Tracker app by importing recorded video. If the video already exists in the Tracker software, we set the video time frame from start to finish with the track and calibrate it. After determining the x and y coordinates of the Gourami, the next step is to analyze the mass point of the Gourami that is determined using the track menu. The Gourami motion was analyzed with an auto-track command to place the frame point on the jump of the Gourami. The data was obtained from two-dimensional vertical and horizontal motion (x,y). The tracker software will display data in the form of kinetic energy, potential energy, and mechanical energy in the Gourami jumping motion.

In estimating the behavioral characteristics of jumping fish in order to obtain accurate data, it is necessary to use specimens that have several different sizes (Parsons et al., 2016). This study uses three types of fish which can be seen in Figure 1.

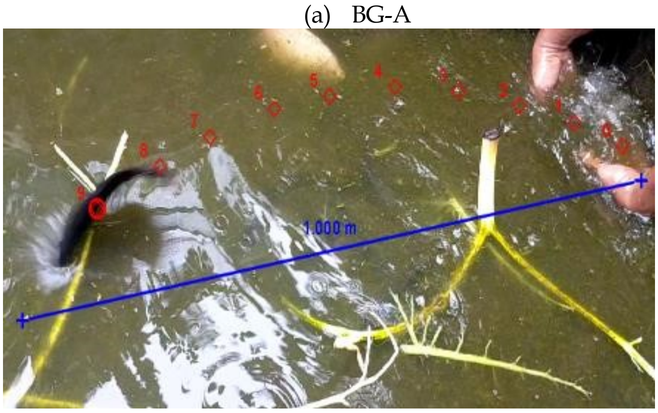
(a) Black Gourami (BG-A) (mass: 0.30 kg; long: 0.25 m

(b) Black Gourami (BG-B) (mass: 0.20 kg; long: 0.17 m)

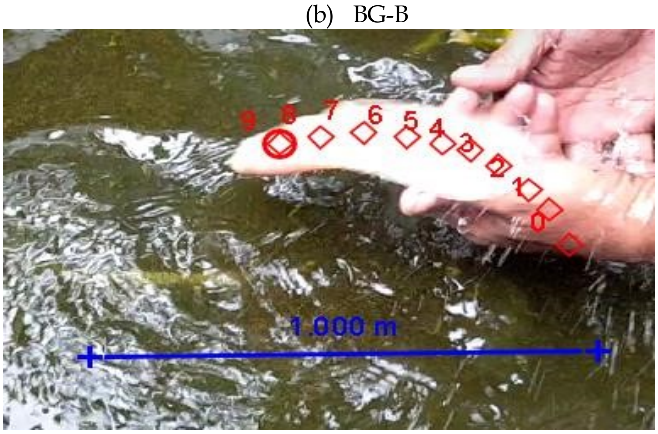
c) Albino Gourami (AG) (mass: 0.25 kg; long: 0.20 m)
Figure 1. Type of gourami fish



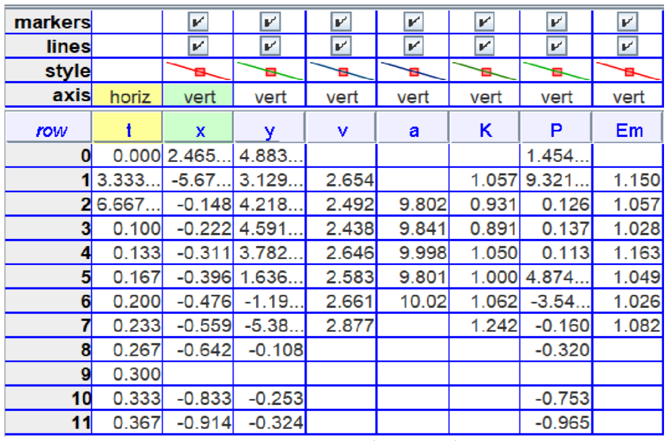
(a) BG-A



(b) BG-B



(c) AG
Figure 2. Gourami jumping motion



markers								
axis	horiz	vert	vert	vert	vert	vert	vert	vert
row	t	x	y	v	a	K	P	Em
0	0.000	2.465...	4.883...				1.454...	
1	3.333...	-5.67...	3.129...	2.654		1.057	9.321...	1.150
2	6.667...	-0.148	4.218...	2.492	9.802	0.931	0.126	1.057
3	0.100	-0.222	4.591...	2.438	9.841	0.891	0.137	1.028
4	0.133	-0.311	3.782...	2.646	9.998	1.050	0.113	1.163
5	0.167	-0.396	1.636...	2.583	9.801	1.000	4.874...	1.049
6	0.200	-0.476	-1.19...	2.661	10.02	1.062	-3.54...	1.026
7	0.233	-0.559	-5.38...	2.877		1.242	-0.160	1.082
8	0.267	-0.642	-0.108				-0.320	
9	0.300							
10	0.333	-0.833	-0.253				-0.753	
11	0.367	-0.914	-0.324				-0.965	

Figure 3. Output Tracker application

Result and Discussion

The results obtained after the video of the jumping motion of Gourami were analyzed with a Tracker software as presented in Table 1.

Table 1. Data of Gourami Jumping Motion

Type of Gourami	Time (s)	Kinetic Energy (J)	Potential Energy (J)	Mechanical Energy (J)
BG-A	3.333	1.057	0.932	1.150
	6.667	0.931	0.126	1.057
	0.100	0.891	0.137	1.028
	0.133	1.050	0.113	1.163
	0.167	1.000	0.049	1.049
	0.200	1.062	-0.036	1.026
BG-B	3.333	0.667	0.059	0.726
	6.667	0.804	0.013	0.907
	0.100	0.904	0.138	1.042
	0.133	0.967	0.153	1.120
	0.167	0.851	0.127	0.978
	0.200	0.873	0.090	0.963
AG	3.333	0.634	0.664	1.298
	6.667	0.563	0.784	1.347
	0.100	0.587	0.908	1.495
	0.133	0.400	0.995	1.395
	0.167	0.690	0.803	1.493
	0.200	0.781	0.980	1.761

The result is that the faster an object moves, the greater its kinetic energy. Likewise, the greater the mass of the object, the greater the kinetic energy. That is because kinetic energy depends on the mass and velocity of fish motion. Mathematically kinetic energy is formulated as follows:

$$Ek = \frac{1}{2} m v^2 \quad (1)$$

From the equation (1) *Ek* as the kinetic energy (J), *m* as the object's mass (kg), *v* as the object's velocity (m/s²). In the research, the object of research uses three variations of Gourami fish with a mass of 0.30 kg (BG-A); 0.25 kg (BG-B) and 0.20 kg (AG) (See Figure 1). The amount of kinetic energy of the three fish is different. The smaller the mass of the Gourami fish, thus the smaller the kinetic energy produced. This research on kinetic energy by Kalhor et al. (2020) to increase kinetic energy requires a certain particle work and speed. Surabidin & Djuhana (2019) explained the greater the mass of the object, the greater the kinetic energy produced.

The motion of the Gourami fish jumping apart from the phenomenon of kinetic energy is also known to have potential energy. Because of this motion, the height of the Gourami fish can be measured. The potential energy value is in accordance with the concept of potential energy physics that the amount of potential energy depends on the height of the object from the earth's surface. Systematically the potential energy equation is written as:

$$Ep = mgh \quad (2)$$

From the equation (2), *Ep* as potential energy (J), *m* as mass of the object (kg), *g* as acceleration due to gravity (m/s^2) and h as height (m). In the research on three types of Gourami fish, the potential energy depends on the jumping height of the Gourami fish, and the greater the mass of the fish, the greater the potential energy. Maison et al. (2020) explained the work and energy of matter. The potential energy is produced by a force that depends on the position of an object relative to its environment. While the higher position of an object the greater the potential energy.

After obtaining the amount of kinetic and potential energy of the jumping Gourami fish, it can be determined the amount of mechanical energy. Mechanical energy is the sum of the kinetic energy and the potential energy of the object. Systematically, mechanical energy can be explained by the following equation.

$$Em = Ek + Ep \quad (3)$$

$$Em = \frac{1}{2}mv^2 + mgh \quad (4)$$

From equation (3), *Em* is as mechanical energy (J), *Ek* is as kinetic energy (J), and *Ep* is as potential energy (J). Previous research by Rumiati et al. (2021) has analyzed the concept of mechanical energy physics in the traditional game of stilts as a physics learning material. The magnitude of potential energy and kinetic energy at the point of each point shows a difference but still tends to be the same. It can be due to the friction of the fish when jumping with the air, which causes the object's speed to be inaccurate. Experiments by utilizing the analysis of this video tracking software can be applied to various physics-based physics experiments so that experiments on the law of conservation of mechanical energy can be proven, which can help students understand science concepts, especially physics.

Conclusion

Video analysis of scientific phenomena using Tracker software can investigate the position, altitude, kinetic energy, potential energy, and mechanical energy of the jumping motion of Gourami fish by visualizing the concept of motion in real-time. In this experiment, the result is that the bigger the fish, the greater the kinetic energy and kinetic energy produced. Kinetic energy depends on the mass and speed of the Gourami fish jumping. While the potential energy depends on the height of the Gourami fish when jumping. It is also affected by the fish's mass and the acceleration of gravity. The video analysis of the motion of the jumping gourami using Tracker can be used in science learning, especially in physics practicum about the law of conservation of mechanical energy. Further research can do the same analysis on other types of fish to compare the motion between Gourami and other fish so that the discussion about the conservation of mechanical energy is more focused.

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