

Research Article

Pascal's Principle Interactive Model for Kinesthetic Learners

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Abstract: This study was conducted to develop an interactive and hands-on educational tool on Pascal's principle that targeted to be used by kinesthetic learners. The Pascal's principle, also known as the principle of transmission of fluid pressure, states that when there is an increase in pressure at any point in an enclosed fluid, the pressure is transmitted equally to all parts of the fluid and the walls of the container. This principle is fundamental in the operation of hydraulic systems. A hydraulic excavator arm utilizes Pascal's principle to perform its work. The arm consists of a series of hydraulic cylinders, pistons, and hoses. When hydraulic fluid is pumped into one side of the cylinder, it exerts pressure on the piston, which in turn generates a force. This force is transmitted through the hydraulic fluid to other connected cylinders in the system. The pressure created by the force is equal in all directions, allowing the excavator arm to move and lift heavy loads with ease.

Keywords: Kinesthetic; interactive; Pascal's principle; hydraulic system; pressure.



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1. INTRODUCTION

Hydraulic system is known as one of the applications of Pascal's Principle where one of the French physicists, Blaise Pascal (1623-1662) stated that the fluids is said to be transmit the energy when contained (Alfred Rupert Hall, 1983). According to Pascal's principle, the pressure exerted on a fluid in a closed system is transmitted undiminished in all directions (Walker et al., 2014). This means that any change in pressure applied to one part of a confined fluid is equally transmitted to all other parts. Hydraulic press was the first hydraulic machine to be invented (Juvinal, 2020). Basically, the fluid contain in the hydraulic press is water which will transmit equally the pressure throughout the confined container.

One of the basic applications of hydraulic system is hydraulic jack and car. The presence of hydraulic concept explained this thing works (Mays, 1999). Two different sizes of piston have created two different forces. When a small force is applied to the small piston of the hand pump, this result in a larger force at the bigger piston on the actuator piston. This is caused by the difference in surface area of the piston. In teaching science subject like Physics, educators have problems in explaining theoretical concept such as Pascal's Principle to the kinesthetic type of students (Research and Innovation in Physics Education: Two Sides of the Same Coin, 2020).

Kinesthetic learners, also known as tactile learners, are individuals who primarily learn and process information through physical movement, touch, and hands-on experiences (Kolb, 2015). They have a strong preference for learning by doing rather than simply observing or listening (Tomlinson & Mctighe, 2006). To support kinesthetic learners, we incorporate hands-on activities, role-playing, interactive demonstrations in teaching methods by developing a Pascal's principle interactive model. This model consists of a moving excavator with 4 different gear (handle) which responsible in controlling the excavator by moving. Each gear is connected to the syringe. By pushing or pulling the syringe, the excavator start moving to the left, moving up, down and the process of extend of the excavator arm will happen. This innovation model can provide opportunities for physical engagement and incorporating movement into the learning process that can greatly enhance their understanding and retention of information.

2. METHOD & MATERIAL

We have analyzed the hydraulic system in the excavator arm. Then, we have developed an innovative model that deals with the hydraulic system to the top of the excavator arm. Firstly, three pieces of cardboard was taken with different measurement which is 7 cm, 20 cm and 23 cm and the holes are make at the opposite end of the pointed side. All other cardboard also must make hole at two opposite ends. Next, the driller was used for making the holes through cardboard. A drink can was taken and cut in a bucket shape. Furthermore, a 20 cm cardboard joined with the drink can that we make in the previous step by using the toothpicks and glue it. Four of 10 ml syringe was taken and placed the tips on the base and handle at top for each part of the arm. The cable tie was used to fix the handle so that the handle does not move.

The arrangement was made to help the excavator moved up and down. In addition, four silicone pipes were taken and fit at the end of each syringe. The attachment was made with another four syringes with respected to their size. Lastly, another four syringe was set up which is act as the controller of the excavator which connected to the syringe at each part of the arm.

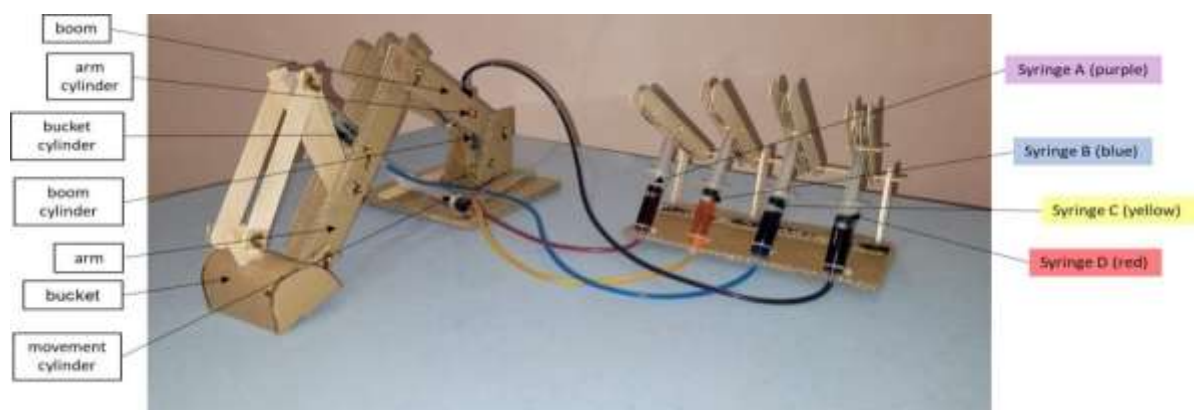


Figure 1. Diagram of Hydraulic Powered Excavator Arm

3. RESULT AND DISCUSSION

Hydraulic systems typically employ incompressible fluids, such as oil or hydraulic fluids. These fluids do not easily compress under pressure, ensuring consistent force transmission and preventing loss of energy due to compression (Custom Manufacturing, Hardware, Rubber and Plastics Guides on Thomasnet, n.d.). As referred to in the diagram above, there are four syringes that are attached to different lengths of silicone pipe, labelled A, B, C, and D. Every connection between the syringes and silicone pipe functions as a handle that will move the components in the excavator. The syringes are filled with different colors of fluid to illustrate the movements, which will be combined to produce an excavator arm that uses a hydraulic system. The function of syringe A (purple) is to move the boom component, which will make the mounted pillar move up and down. Meanwhile, syringe B (blue) is connected to the bucket, which is used to scoop things. Next, syringe C (yellow), which attaches to the arm cylinder, will perform the stretch from back to front. The last syringe, which is syringe D (red), is used to move the excavator from left to right.

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Based on the outcome, this hydraulic system applied Pascal's principle which relates to pressure, force, and surface area. According to the Khayal (2017) The Pascal's law, which states that pressure in an enclosed fluid is uniform in all directions, is the basis on which the hydraulic system operates. Pressure P can be expressed by the following formula as force per unit area, $P=F/A$, which is P is pressure and the unit is in Pascal (Pa), A is area where the force is applied and its units is (m^2), and F is force where the units is Newton (N). One of the key advantages of hydraulic systems is their ability to multiply force. Due to the transmission of pressure, a small force applied to a small piston can generate a larger force at a larger piston. This force multiplication allows hydraulic systems to provide substantial power and control in various applications, such as heavy machinery, automotive braking systems, and hydraulic presses (Saeed Moaveni, 2015).

Since in this project we used different size of syringe, and it is related to the Pascal principle which is the differentiation of area. Since the pressure is the same in both directions, the larger piston will produce a greater force by applying a smaller force at the small piston. As a result, the piston travel distance is decreased by having a greater cross-sectional area. The flow rate is the amount of distance travelled in each amount of time, or the cross product of speed and cross-sectional area. The syringe used in this project is a cylindrical syringe. So, the area to calculated is using the sum of the surface area for the cylinder which is $A=\pi r^2$. Based on the design of this project, we use a small syringe on each controller so that the force applied is also small while for the moving of the excavator, we use a large syringe so that when the force is applied it is large and it can lift the excavator arm or move the excavator. The height that used for both syringes are same however the diameter is different.

4. CONCLUSION

In conclusion, the successful study and manufacture of a hydraulic excavator system based on the Pascal Principle represents a remarkable achievement with the potential to significantly benefit kinesthetic learners. This project has not only advanced the field of hydraulic engineering and construction machinery but has also opened new avenues for enhanced educational experiences for those who thrive through hands-on learning. Our research and development efforts have led to the creation of a hydraulic excavator system that provides a unique platform for kinesthetic learners to engage with complex engineering concepts. By utilizing the principles of Pascal, we have not only developed a powerful and efficient excavator system but also a tangible and interactive educational tool. Kinesthetic learners, who learn best through physical activities and tactile experiences, will find our hydraulic excavator system an invaluable resource for grasping the intricacies of hydraulic engineering. Through hands-on interaction with the excavator's controls and systems, learners can gain a deep understanding of the Pascal Principle, fluid dynamics, and mechanical processes, making

abstract concepts more accessible and engaging. By creating a product that can be used as an educational tool, we bridge the gap between theoretical knowledge and practical application, thereby fostering a generation of engineers and technicians who are well-equipped with a holistic understanding of hydraulic systems. Our hydraulic excavator system has the potential to revolutionize the way we teach and learn about hydraulic engineering, benefitting kinesthetic learners and many others who stand to gain from a more interactive and experiential approach to education. This innovation not only propels the field of hydraulic machinery forward but also contributes to the development of a more inclusive and effective learning environment.

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