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Application of simulation in 3D space to teaching and science research

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ABSTRACT

This article introduces the general issues and benefits of simulation in teaching and scientific research. Thereby, the author illustrates by making 3D drawings, assemblies, videos simulating machine structures for teaching Theoretical mechanics, Construction machine subjects and the author's studies in the mechanical field.

The application of simulation in teaching is to create videos by using Solidworks software, simulating the operating principle of machine structures. After that, show the videos to the students, excite them and make the lesson lively. And the simulation application in scientific research is mentioned as the way to use 3D drawings and simulation videos to preview the research results, promptly fix the wrong places. Since then, the research is quick, cost reduction is not worth it.

The results of this paper are to point out the unique benefits that contribute positively to simulation in teaching and in scientific research.

Key words**:** *cranes, figures, hoists, schemas, simulations*

1. Introduction

Simulation**:** Simulation is a method of building a model based mainly on 3D (3-dimensional) and for that model to work properly or close to the operating principle of

things and phenomena in reality. From there, we better understand the nature of things and phenomena and have a way to apply them to life. As we know, many people use computer software to simulate lightning in a thunderstorm, simulate the deformation of materials when bearing, simulate electric current flowing in a wire, simulating electrons orbiting the nucleus, simulating the movement of magnetic field lines around the magnet, simulating the working principle of machines, etc. All of this is very interesting.

***Figure in engineering and simulation of figure activity*:** The figure is a specific feature of the subjects of the technical discipline. In a sense, the figure is the "communication language" between people doing technical work together. Teaching and researching multi-disciplined subjects requires reasonable methods to succeed. We read and understand the drawings related to the subject as if we have partially acquired the knowledge of that subject. Currently, the figure in textbooks and science and technology books are mostly flat, drawn from the time when 3D graphic software was not widely used. This makes the textbook reader have to imagine, infer these flat shapes into space. That process of imagination and deduction must have been inevitable mistake and deadlock.

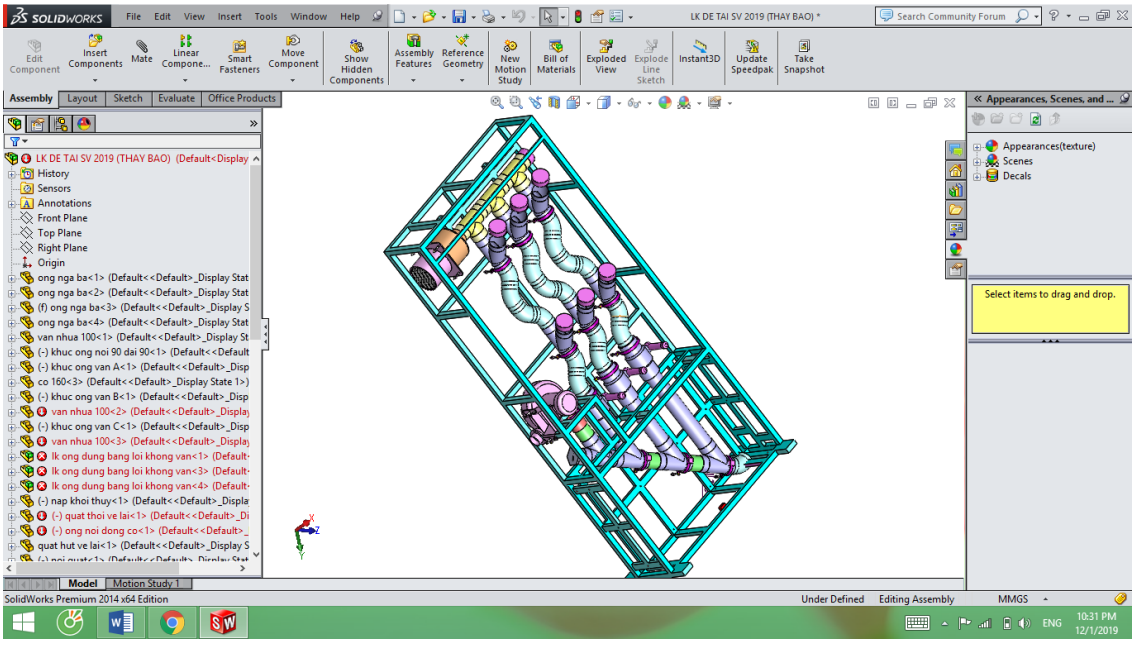


Figure 1. The screen of the Solidworks software

Today, graphical software is very helpful for technicians in drawing 3D figure, simulating states to preview the results of the projects that they are about to perform. From there, technicians see their mistakes and fix them right before the construction of

the project. In teaching and scientific research, too, we should apply the simulation capabilities of such graphic software to reduce the inference when we encounter technical drawings, mechanical principle diagrams, etc. That reduces the unfortunate errors. For example, if we want to design and build a machine, but we only use 2D drawings on AutoCad as before, our design and manufacturing are very time consuming. On the contrary, if we use 3D drawings to assemble, simulate and preview the results of the operating principles of that machine, our research and manufacturing are very quick. Because at that time, we had a visual, comprehensive view of the machine we wanted to make.

2. Application of simulation into teaching

2.1. Application of simulation when lecturing

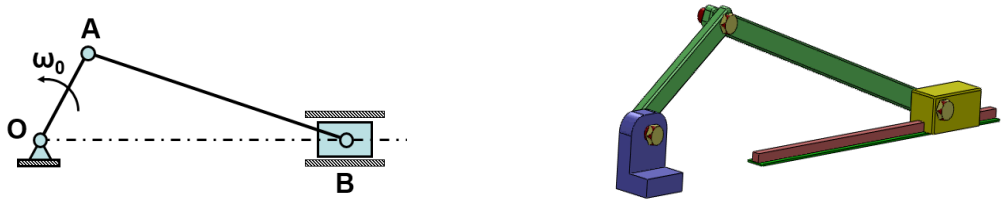
Currently, most universities and colleges throughout the country, each classroom is equipped with a projector. This is very convenient for teachers to present vivid images to illustrate the lecture, to inspire learners. However, we do not discuss here is the use of PowerPoint effects to present a static drawings in a plane. Which we use specialized graphics software such as AutoCad 3D, Solidworks, Inventor, Catia, ... to draw and make motion simulation videos in 3D space of technical structures, simulation principles of equipment in mechanical engineering, construction, architecture, environment... These specialized software represent movements in space in true or approximate manner according to technical language. After you have the simulation movie, we just need to use PowerPoint to show.

To illustrate, we use drawings in the curriculum of Theoretical Mechanics and Construction machinery as an example (see sections 2.2 and 2.3). The drawings mentioned in these two subjects have many types, they are: schemas, technical drawings, structural principle diagrams, operation principle diagrams of construction machines, ...

Considering specific problems through the Theoretical Mechanics subject. When lecturing on the handwheel mechanism - slider as shown in Figure 2a, the lecturer said: "When the OA bar is rotated around the fixed O point, the AB bar is moving flat, the B slider is moving in the groove". That said, the students will have many doubts, not knowing when the moving parts, they will hinder each other? How did they move that way?

Indeed, the reality of teaching shows that some students still do not understand, or understand vaguely, imagine, infer different types, do not know how the motions. Some students have the courage to ask the lecturer again, but the problem has not been completely solved, because "Looking at the quiet image in the plane and imagining the

animation in space" may be wrong. If at the same time, the instructor opens a video to simulate the movement of the handwheel mechanism - slider as shown in Figure 2b, the situation will be more comfortable, the students will easily understand the lesson and be more interested in learning, the lecturers will be less tired.



a) Schema *b) Figure simulation*

Figure 2. Handwheel mechanism - slider

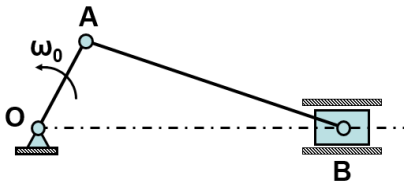
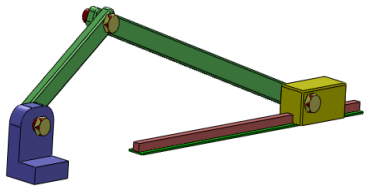
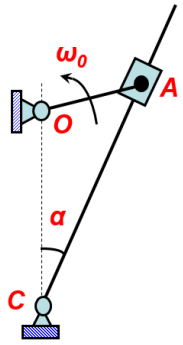
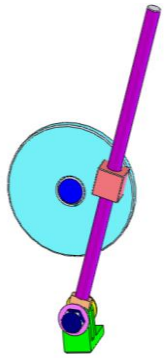
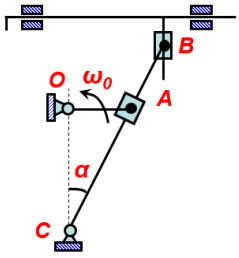
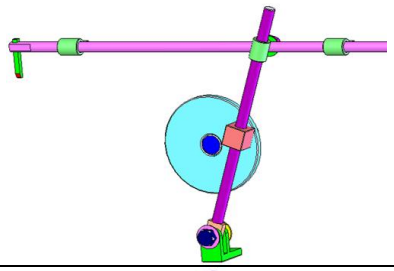
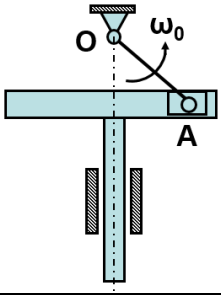
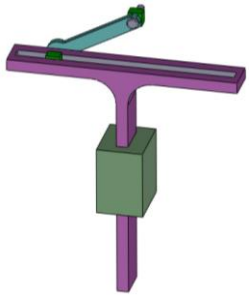
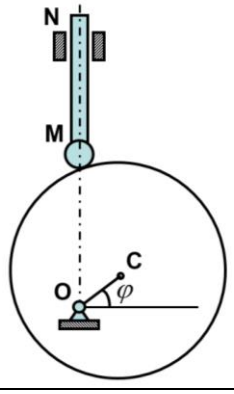
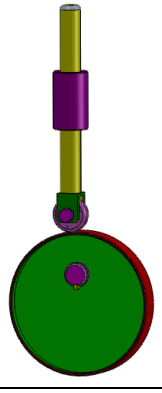
2.2. Application of simulation when instructing to solve exercises

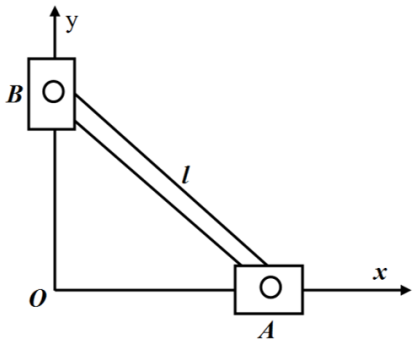
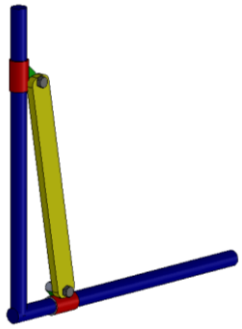
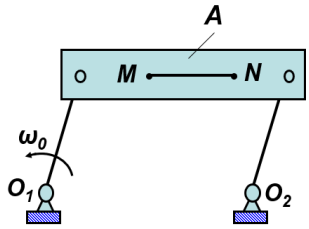
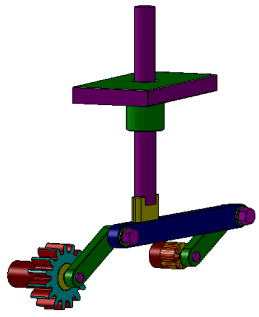
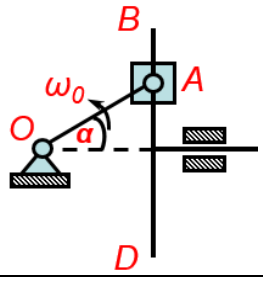
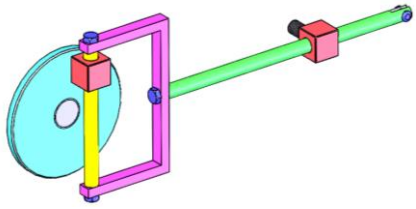
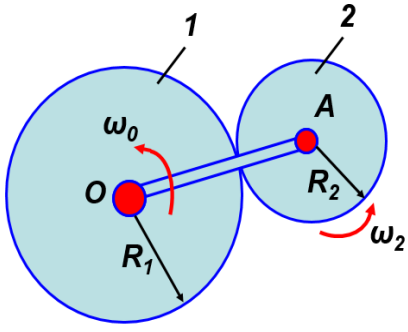
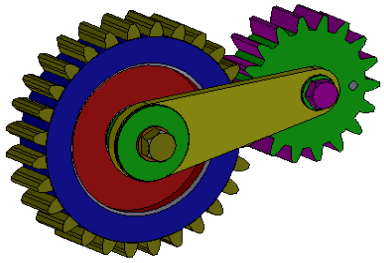
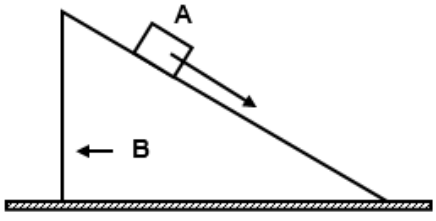
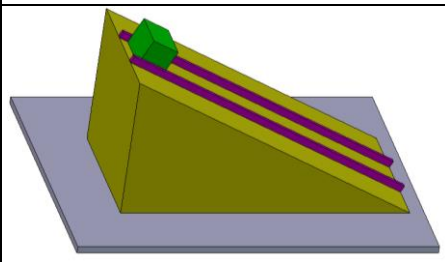
We all know that in order to properly solve physical exercises, students must understand the probable nature of things and phenomena. Mechanics is a field of physics, most mechanical exercises are accompanied by drawings of the mechanical systems. Knowing the principles of movement of the system and the learned formulas, students will solve the exercises correctly. However, the reality shows that mechanical exercises are too difficult for many students. Most students do not understand the principles of movement of the system, deduce many different types, lead to wrong solutions, or fail to do the exercises. To reduce difficulties for students, according to the author of this article, the application of simulation in 3-dimensional space to teach theoretical mechanics subject is very necessary. Through this method, students understand the principle of moving objects, the nature of the problem, thereby solving the problem correctly.

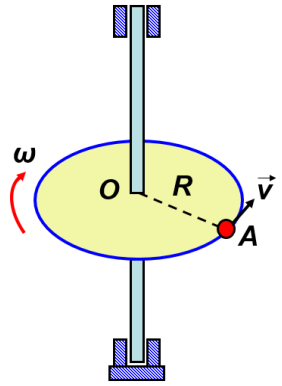
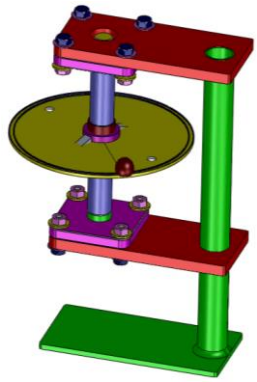
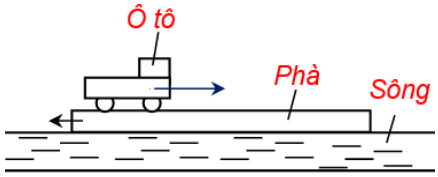
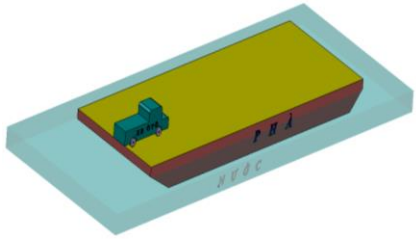
When teaching and learning mechanical subjects such as: Mechanical Engineering, Theoretical Mechanics, Structural Mechanics, Material Strength, ... we often see the concept of "schema", that is, using simple drawings to represent show the structure, the machine details. Using a schema is somewhat quick, but behind it is the thinking, imagination of readers about the product in reality. Which was imagination then make mistakes. Therefore, when teaching we need to use schemas and use 3D images or simulated videos, the lesson will be successful, the teachers will work hard, the learners will also be easier to understand and interested in learning.

Table 1 shows the structure diagrams (Theoretical Mechanics subject) and the accompanying 3D figure. From this 3D image, we can simulate on the computer to see how the mechanism works.

TABLE 1. Common machine structures

No.	*Name of structure*	*Schema*	*3D images (also simulated videos made by the author)*
1	Handwheel mechanism - slider		
2	The culit structure		
3	Horizontal planning machine structure		
4	Sine structure (turning rotary motion into translational motion)		
5	Cam structure		

6	Elliptical arc structure		
7	4-stage hinge mechanism (for application in presses)		
8	The structure of the OA bar spins and the BD bar progresses		
9	Structure of artifacts showing 2 parallel movements (combining 2 rotating motions)		
10	The mechanisms represent the law of conservation of momentum. - The thing that slides on		

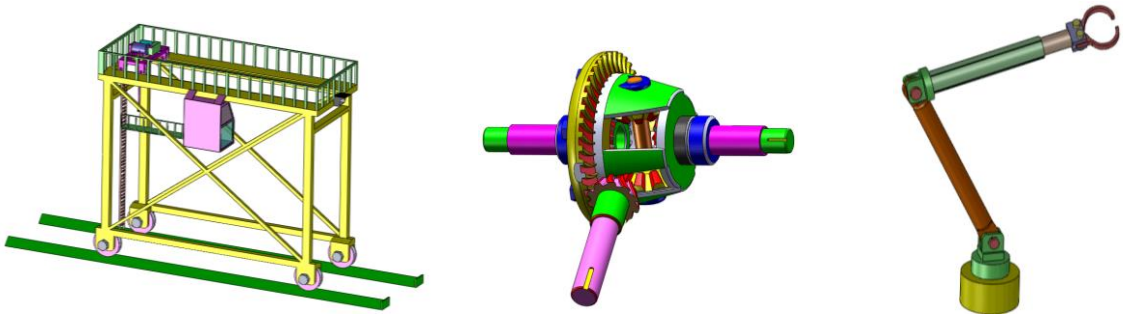
	the tilted wedge, the wedge is backward. - If the object rolls on the disc, the disc will reverse. - Cars running on the ferry make the ferry back a bit.		
			

2.3. Application of simulation when lecturing on the operating principle of construction machinery

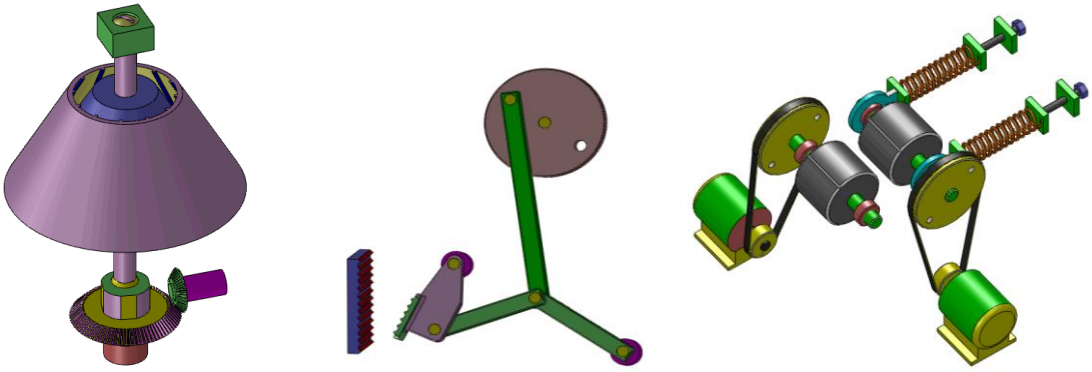
In order to understand machines and equipment, students must first understand the working principles of such machines and equipment. Talking about the working principle of a device is talking about how the device works to serve people. However, the curriculum only draws the device in 2D (two-dimensional) shape and explains in words the operating principle of that device. Students read the syllabus, the teacher explained more, but the students' understanding level was not high, looking at the static image but judging for animation, deducing many types, even deviating the problem.

By using specialized graphic software, the ability to understand mechanical equipment, construction, lecturers can draw and simulate the internal structure of the construction machine while the machine is working, then slide show for students to see. This is really effective for teaching and learning. Figure 3 shows some construction machine models drawn and simulated by the author.

Currently, there are many construction machines on the internet, but most of them show us their appearance, we don't know how the internal mechanism works. Therefore, to help students, lecturers need to use specialized graphics software such as Solidworks, Catia, Inventor, ... to draw, simulate the inner work of equipment and machines to help students.



a) Gantry crane *b) Differential structure (in a car)* *c) Robot arm*



d) Cone cone crusher *e) Jaw crusher (crushing stone)* *f) Double shaft crusher*

g) Hoist *h) Tower crane* *i) Lifting equipment*

Figure 3. 3D images and video simulating the working principle of construction machine (The author uses Solidworks software to implement)

3. Application of simulation into scientific research

3.1. Theoretical basis

In scientific research, the simulation gives us a lot of advantages, most notably to give us a visual look, to preview the results we want to work towards. Since then, our research has been easy, with little effort and cost, when project projection before the judges also went smoothly, everyone immediately understood the problem.

For example, when we use 3D drawings combined with simulation to preview the results of the operation of a certain machine, we have a full view of the machine we want to do. When we send a 3D drawing to place a machine manufacturer, that worker is easy to understand, we do not have to spend a lot of time explaining. In fact, there are complex machine details, when drawing 2D, it is necessary to use very detailed cut, extracted pictures, even very skilled workers take a lot of time to read and understand drawings. And when we use a combination of 2D and 3D drawings, both we and the workers understand and work very comfortably. Therefore, the creation of that machine is very convenient.

3.2. The application of simulation in some scientific research projects of the author

a) Design and manufacture a model of tower crane and construction hoist (Figure 4): This is a school-level scientific research project in 2016. The author has completed this topic before 3 months due to use. 3D drawings and simulation of preview results. The following are excerpts from some major simulations.

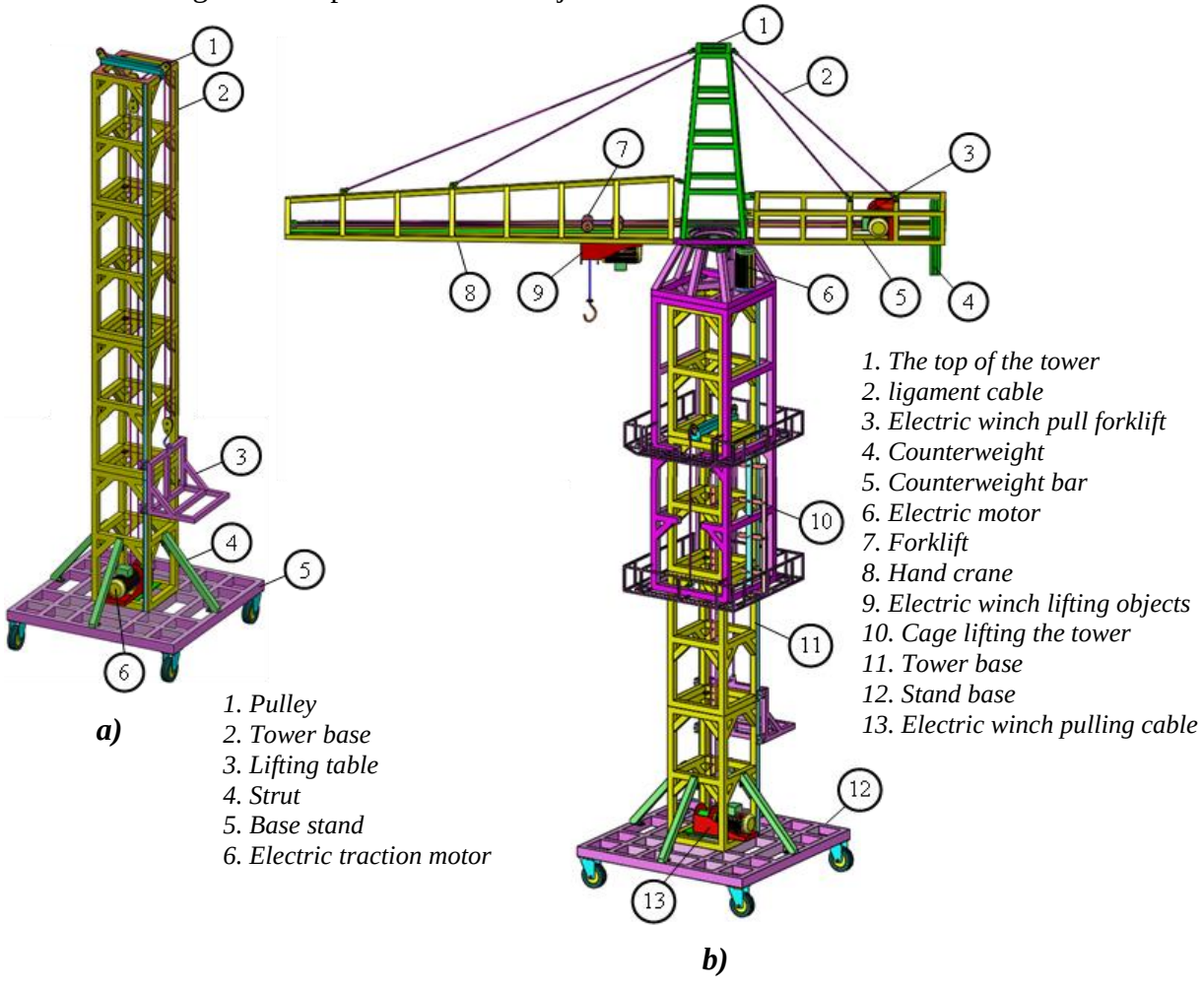
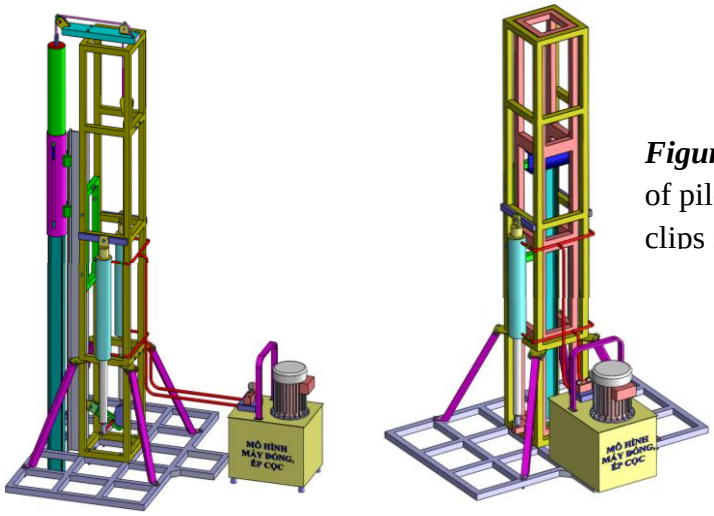


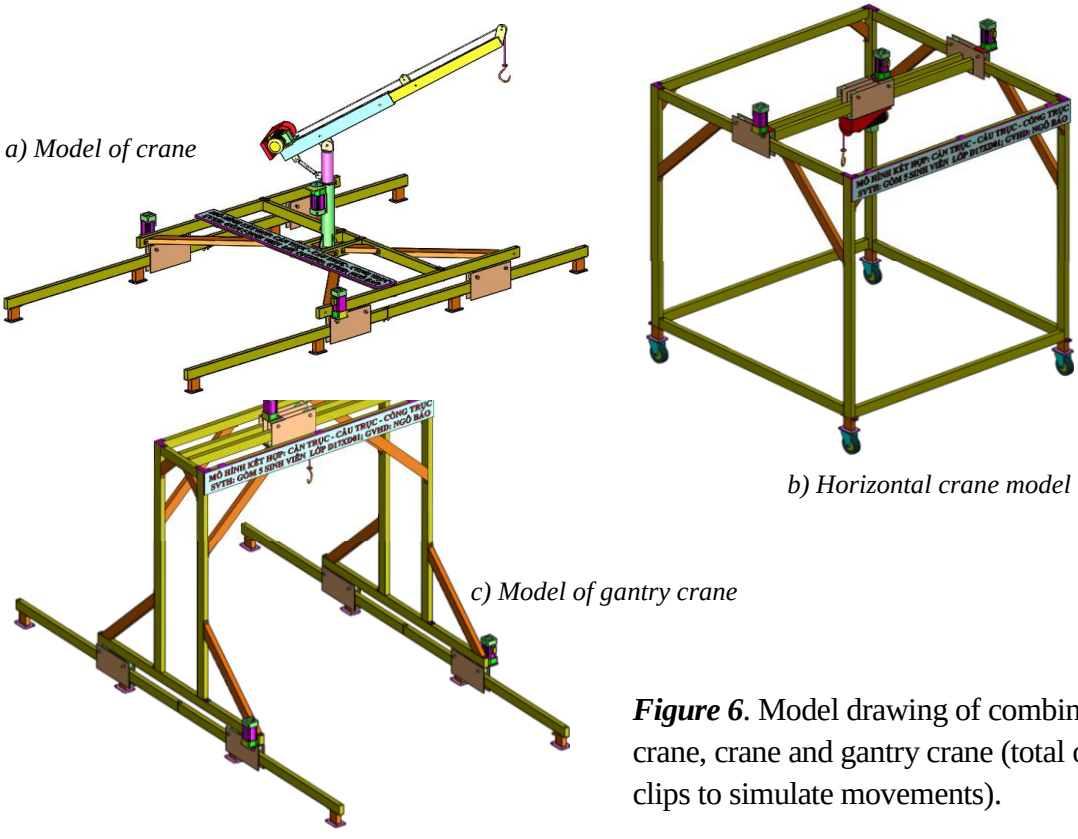
Figure 4. Model assembly drawing of a crane and hoist (There are a total of 6 clips simulating the principle of operation).

b) Design and manufacture of models incorporating pile driving and pressing machines (Figure 5): This is a research topic evaluated by the jury with many advantages for being new and creative, combining 2 models into 1 model, significantly reducing manufacturing costs and saving storage space. The author also used simulation that the research was successful.



a) Piling machine model *b) Model of pile presses*

Figure 5. Model assembly drawing of pile driving machine (a total of 4 clips simulating movements)



a) Model of crane

b) Horizontal crane model

c) Model of gantry crane

Figure 6. Model drawing of combined crane, crane and gantry crane (total of 6 clips to simulate movements).

c) Design and manufacture of combined models of crane, crane and gantry crane (Figure 6): This research topic has also been evaluated by many judges because of its new and innovative features. 3 models into 1 model, significantly reducing fabrication costs and saving storage space.

4. Conclusion

Using computer software to simulate true or slightly true to the principle of operation of things, the phenomenon has great significance in teaching and in scientific research. Simulation helps us better understand the nature of things and phenomena and have a way to apply them to life.

The author has theorized and presented 3D images, videos simulating many mechanisms of machinery, equipment for teaching and scientific research to clarify the value of simulation. Indeed, simulation gives us the following benefits:

- Students easily understand the lesson, and understand the true nature of the problem.
- Clarify what the teacher wants to say.
- Causing attention, stimulating learning passion for students.
- Increase teaching and learning productivity (lecturers do not have to spend a lot of time to guide students to imagine from still images to animation).
- Increase productivity and reduce scientific research costs.

When drawing 3D images and making simulation videos, the instruction manuals of Solidworks, Inventor, Catia, etc,… mentioned. Lecturers and students of engineering disciplines can learn and do this by themselves.

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