# Kinematics Simulation with Mobile App Approachment

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## ABSTRACT
Kinematics is one of the difficult subjects for engineering students. This difficulty is partly due to the difficulty of visualizing various movement mechanisms that occur in a mechanical structure. This movement mechanism is influenced by both the type and characteristic of the joint used. This article contains the results of applied research in developing simulation software that can simulate various kinematic movement mechanisms according to the type of joint used. This research uses a positivism research approach because it is based purely on facts. The quantitative method as one of the typical methods in the positivism research approach is selected. Its stage includes identify a problem, literature review, specify a purpose, collect data, analyze data, and report. In the collection and analysis stage, the interview is done to find more information on the model of kinematic joint motion. A functional and non-functional requirement is formulated in this stage. In addition to the system is modeled using the Unified Modelling Language (UML) tool and object-oriented approach is taken to implement the model. Manual testing is used to test this software based on test cases to develop previously. The final outcome of this research is a mobile app as a software simulation tool for kinematics education is resulted.

## General Terms
Software, engineering, modelling

## Keywords
Kinematics, simulation, mechanical structure, joint, UML

## 1. INTRODUCTION
In the initial stages of the process of designing a machine mechanism, it is necessary to first analyze the mechanism of movement and speed of each component in order to satisfy the overall function of the machine. The motion of components that form a mechanism is an important concept learned in kinematics [1]. Motion in a machining mechanism is determined by the joint. Understanding the joint correctly will help students and practioners in designing machinery structures or constructions. Joint has many types and each type has a different structure and function

Understanding the principles of motion and joint work in kinematics is not easy and this is often a major obstacle for students in learning engineering mechanics. Students often experience difficulty in visualizing joint movements. This difficulty affects the ability to design construction or machinery structures. The inability to visualize joint motion will affect the accuracy of the calculation techniques that will be used to determine the size and dimensions of the material, the type of material and other material treatments.

The use of software in the world of education has been very helpful in achieving what are the learning objectives. Various software both web-based, mobile or desktop have been made to support learning activities including distance learning. Simulation software has proven to be very effective in visualizing teaching materials which are characterized by the ease of students in understanding the material being taught.

## 2. LITERATURE REVIEW
### 2.1 Kinematics
Kinematics is a field of study that studies the relative motion of machine elements, namely their speed and acceleration. The speed and acceleration are obtained in a form that is useful as information to obtain dynamic forces acting on those machine elements[1]. In learning kinematics, modelling kinematis diagram In studying kinematics, kinematics diagram modeling in the form of attaching an identity or numbering to each connecting rod is carried out to facilitate understanding. The following figure is the kinematic mechanism of motion in the combustion motor

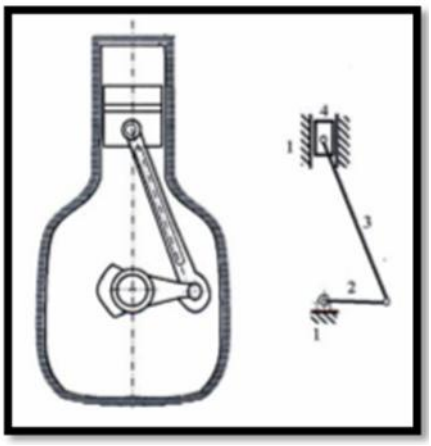


**Fig 1: The kinematic mechanism**

In the above figure the connecting rods of static parts are marked with the number one so that it can be said as a connecting rod one. Connecting rod one is a reference of all positions, velocity, and acceleration of other connecting rods that are relative to it.

### 2.2 Kinematics Joint
In order to connect components of a system or machine, joints are used. These mechanical joints may be temporary or permanent depending on whether it is necessary to remove the link frequently or not at all. Joint is closely related to a mechanism's movement. The resulting movement to operate a system is determined by the linking kinematic joints of the system members[2].

The kinematic joints enable and restrict movement in some directions. The kinds of permitted and restricted movements are linked to a joint's degree of freedom. The Kinematic Joints are basically categorized into three classifications based on

the sort of contact that is made between the two members. They are lower pair joint, higher pair joint and compound joint[2].

In lower pair joint, members of mechanism have area contact between the two mating surfaces. Therefore,the contact stress of lower pair joint is smaller than higher pair joint. Lower pair joints have a lengthy service life as wear and stress spread across bigger contact surfaces and enable better lubrication. The degrees of freeedom for a lower pair joint are generally smaller as the necessity for area contact between the members restricts the joint's geometry. Distance joint, piston joint, pulley joint, gear joint and weld joint are examples of lower pair joints. In higher pair joint, the contact between the two members has point or line geometry. Due to the very tiny contact region, the contact stress for a higher pair joint is large.

## 2.3 Simulation Software

Simulation software enables engineers predict a system's conduct. It used to assess a fresh design, diagnose issues with an current design, and test a system under hard-to-reproduce circumstances, such as an outer space satellite[3]. Engineers need a system mathematical model to operate a simulation, which can be displayed as a block diagram, schematic, statechart, or even code. The simulation software calculates the model's conduct as circumstances develop over time or as occurrences happen. Simulation software also involves instruments for visualization, such as information display and 3D simulation, to assist track simulation as it operates.

Engineers and scientists use simulation software for a variety of reasons:

- Model creation and simulation is less costly than hardware prototyping and screening
- Simulation software can be used before constructing one in hardware to test distinct designs.
- Simulation software is linked to the hardware to test the complete design integration

A software for simulation is a software model that enables us to show its main features and activities. We can demonstrate our customers how everything operates in our program using software simulations[4].

# 3. RESEARCH METHODOLOGY

This research uses positivism research approach because it is based purely on facts. According to [5] there are five main principles of positivism research, e.g :

- There are no differences in the logic of inquiry across sciences.
- The research should aim to explain and predict.
- Research should be empirically observable via human senses. Inductive reasoning should be used to develop statements (hypotheses) to be tested during the research process.
- Science is not the same as the common sense. The common sense should not be allowed to bias the research findings.
- Science must be value-free and it should be judged only by logic.

It is clear as stated above that positivism approach is appropriate with this research software simulation tool for kinematics education.

According to John Dudovskiy positivism research approach has some typical methods, namely deductive, highly structured, large samples, measurement, and quantitative method. For this research quantitative method is selected and the stages of it can be seen in the figure below [6]:

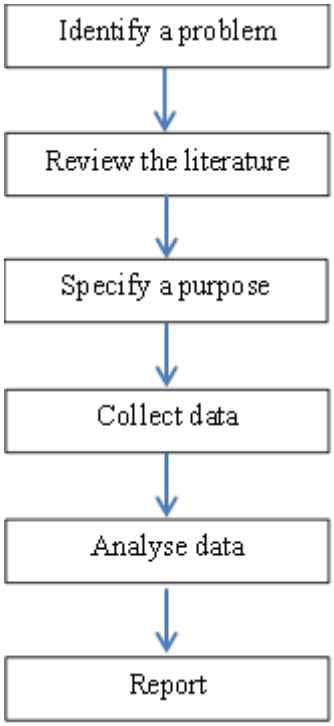


**Fig 2: Quantitative method stages**

In order to collect, analyse and model the data, Unified Modelling Language tool is used and then. object oriented approach is taken to implement the system

# 4. RESULT AND DISCUSSION

## 4.1 Functional Requirement

A functional requirement describes a system or its element in software engineering. It defines the tasks to be performed by a software[7]. A feature is merely inputs, conduct, and outputs. It can be a calculation, information manipulation, business process, user interaction, or any other particular features that define what a system is likely to conduct. Also called Functional Specification are functional requirements. Functional requirement assists us capture the system's intended behavior. This conduct can be articulated as functions, services or tasks, or which system needs to be performed[7].

The functional requirements for this simulation software are as follows

**Table 1. Functional Requirement (FR)**

| No | Description |
|---|---|
| FR 1 | Software system able to link to each kinematics joint simulation screen |
| FR 2 | Software system can simulate kinematics motion based on selected joint's type |
| FR 3 | Software system can move from one simulation window to others |

| | |
|---|---|
| FR 4 | Software system can show rotary motion of a member in a mechanism when pivot or revolute joint is used |
| FR 5` | Software system can simulate fixed distance of two members connected using distance joint. One of the member doing kinematic motion but the member's distance remains constant |
| FR 6 | Software system must simulate restricted motion along vertical axis when piston joint is selected into a mechanism |
| FR 7 | Software system can simulate translational (directional) friction as well as angular (rotational) friction between two objects when friction joint is selected |
| FR 8 | System software can simulate kinematic motion like piston joint, except that the attached body can rotate freely |
| FR 9 | Software can simulate the mechanism of motion where when a pulley joint is used then an object being pulled or pushed with a certain force, other objects will be able to compensate for the mechanism. |
| FR 10 | Software can simulate the gear mechanism |

## 4.2 Non – Functional Requirement

The quality attribute of a software system is defined by a non-functional requirement. They are a set of norms used to judge a system's particular operation. To guarantee the usability and efficiency of the entire software system, a non-functional requirement is crucial. Failure to satisfy non-functional requirements may lead to failure of systems[7].

The non-functional requirement ot this system are :

- The software should be portable
- The software is easy to learn, operate through interaction with interface.
- The software can be executed in mobile device with 1GB memory.

## 4.3 System Modeling

System modeling is the method of creating a system's abstract models, with each model providing a distinct view of that system or viewpoint. It is about representing a system using some sort of graphical notation, now almost always based on Unified Modeling Language (UML) notations[8]. Models help the analyst comprehend the system's features; they are used for customer communication.

Models can describe the system from different views:

- An external perspective in which analysts shape the system context or atmosphere.
- An internal perspective where analysts model the relationships between the system and its environment or between the system parts..
- A structural perspective in which analysts model the system organisation or information structure processed by the system.
- A behavioral perspective in which analysts model the system's dynamic conduct and how it reacts to occurrences.

This simulation software is build on mobile app and its design is modeled using use case diagram and class diagram (just include some method,properties for each class) as follows :

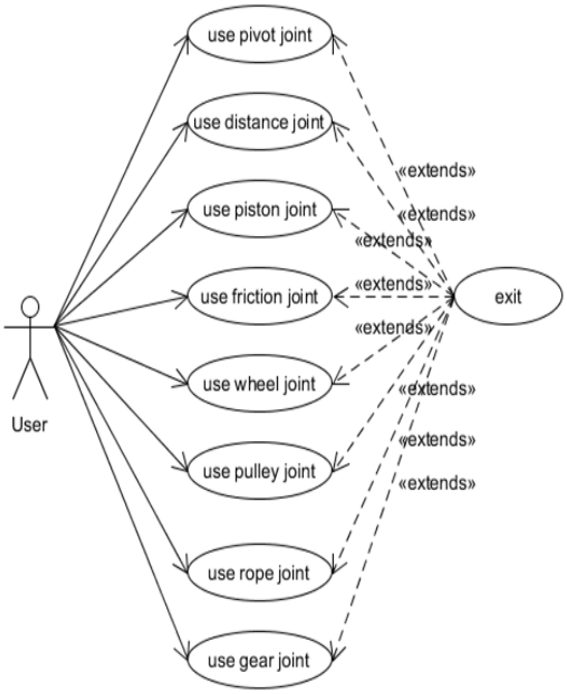


**Fig 3: Use Case Diagram**

## 4.4 Implementation

Using android SDK, the results of the past modeling scheme are applied in mobile applications. The layout of the application is created using XML and the business logic uses java. The final results of this software for kinematics joint motion simulation are shown below Fig. 5,6,7

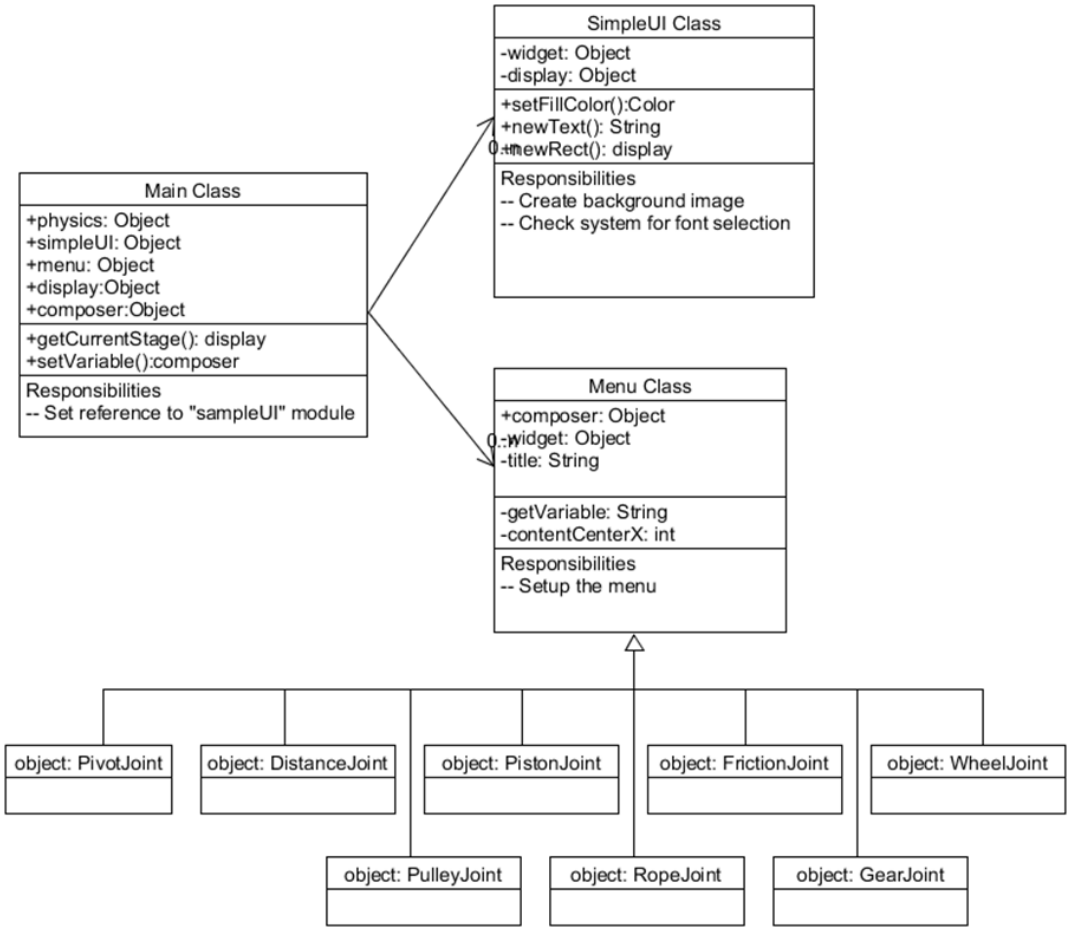


**Fig 4: Class Diagram**


**Fig 5: Main Window**


**Fig 6: Gear Joint**


**Fig 7: Wheel Joint**

## 4.6 Testing

Software testing is an activity that ensures that the actual results match the anticipated outcomes and that the software system is free of defects. To assess one or more interesting characteristics, it includes the execution of a software component or system element. Typically, there are three categories of testing,e.g : functional testing, non-functional testing and maintenance. This system uses functional and non-functional testing.

Functional testing in software testing is a system functionality testing method and guarantees that the system works according to the functionalities indicated in the functional requirement. The aim of this test is to verify the functionality of the scheme. In order to verify the functionality of this system, test cases are set and executed as follows :

**Tabel 2. Test Cases**

| Test Case ID | Test Scenario | Expected Result | Actual Result | Pass / Fail |
|---|---|---|---|---|
| TU01 | Check kinematic motion with pivot joint | Rotary motion | Rotary motion | Pass |
| TU02 | Check kinematic motion with distance joint | Distance between two points in two bodies dosen not cahnge | Distance between two points in two bodies dosen not cahnge | Pass |
| TU03 | Check kinematic motion with piston joint | Restricted motion along vertical axis | Restricted motion along vertical axis | Pass |
| TU04 | Check kinematic motion with friction joint | Translational (directional) friction as well as angular (rotational) friction between two objects | Translational (directional) friction as well as angular (rotational) friction between two objects | Pass` |
| TU05 | Check kinematic motion with wheel joint | Restricted motion along vertical axis and the attached body can rotate freely | Restricted motion along vertical axis and the attached body can rotate freely | Pass` |
| TU06 | Check kinematic motion with pulley joint | The force exerted in the form of a pull or push on a body will be compensated by another body | The force exerted in the form of a pull or push on a body will be compensated by another body | Pass |
| TU07 | Check kinematic motion with gear joint | Gear simulation can be displayed | Gear simulation can be displayed | Pass |

## 5. CONCLUSION

Software simulation tool can be a powerfull tool to simulate how kinematic joint motions work. By using this simulation software, students can visualize kinematic motions and it can help them to learn joint as a part of mechanics subject. On the other hand, practioners can use this software to help them in designing structure and machine construction. This software is developed using object oriented approach and it used UML to model the system overall

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