DYNAMIC BALANCING OF HEAVILEY LOADED TROLLY

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Abstract: *The proposed idea is based on building an automated hydraulic system for balancing a tractor's trolley, which can prevent the rollover of overloaded trolley and can also inform the driver about tilting or shift of center of gravity of the trolley using accelerometer sensor, Arduino and hydraulic cylinders.*

Keywords: ***Center of Gravity, Automation, Accelerometer, Arduino, Hydraulics***

1. Introduction

In India, transportation itself accounts for the 6% to 12% of the total GDP growth. A good transportation system can widen the dimensions for the market of vivid products. The resources which help to produce the proper infrastructures, monuments, territories, buildings need the raw materials. The transportation is the key medium for the transfer of these materials.

One of the most un-noted areas when talking about the transportation is the agriculture. The agriculture and allied sectors have 20.19% shares in the GDP of the country. The agriculture when viewed as a business needs transportation for its growth. The transfer of raw materials, the goods, grains are all transported by means of trollies and tractors. Those are the major mediums of transportation. Many farmers who produce the sugarcane uses tractor to transport the sugarcane to the factory for further processing. The season of sugarcane harvesting comes every year almost for the widespan of 3 to 4 months. The transportation of the sugarcane is most tedious task to do. It requires lot of effort to transport the sugarcane to factory. The owners of the tractors for sake of reducing the cycles of transportation fill the trollies out of their limits as shown in the figure 1.

Figure 1 Loaded Sugarcane Trolley

Overloaded vehicles accounted for a share of 6.7 percent of total accidents, 7.9 percent of total killed and 7.2 percent of the injured in 2020. Thus, the drivers of the trollies travel with such heavy loads through the insurmountable places like villages, mountains, turnings. They drive such a heavily filled and overload trollies that they even sometimes lose the control over the driving. As result we have seen many news where it is reported that the sugarcane truck fell in the rivers, or accidents happened due to the slip of sugarcane trollies. The balance of the sugarcane loses due to the loss of center of gravity. It causes many losses to the farmers. Even farmers bear lots of losses due to the draught, excess rainfall. And the loss due to such casualties contributes more to it. So, it is taken to be on the serious note and we need to solve the issue. So, we are proposing the further project.

2. Literature Survey

Inclination sensing uses gravity vector and its projection on the axes of the accelerometer to govern the tilt angles. The first major benefit of using a second axis is due to the orthogonality of the axes. As in the single axis solution, the acceleration detected by the x-axis is proportional to the sine of the angle of inclination. The ADXL335 is a complete small, thin, low power, complete 3-axis MEMS based accelerometer with signal conditioning voltage outputs accelerometer measurement system [2-4][1]

Calculation for the design purpose for hydraulic cylinder, piston, and hydraulic system. About Hydraulic jack it states that it is a device that is used for lifting heavy materials by the application of much smaller force. It based on Pascal's law, which states that intensity of pressure is transmitted equally in all directions through a mass of fluid at rest. Hydraulic jack used in trolley plays a vital role to lift & unload heavy materials. This project is used to perform the operation of lifting heavy-weight materials. This project also studies the importance of hydraulic circuit systems. Various parts of the modern trolley were studied and their performance was analyzed in terms of the work. Further review is made on the practical plastic model of the project with analysis of working and with the help of hydraulic system lifting operations can be easily carried out without much effort and without outsourcing. [1-2][2]

Development of 3 way dumping trolley to overcome the conventional one-way dumping trolley to advancing version for dumping left side and right side. This three-axis modern trolley is nothing but one of the lifting systems in automobile. In this, lifting system is pneumatically operated. Here the pneumatic cylinder and directional control valve is provided the system. This project work is an excellent solution to bridge the gates between institutions and industries. In this project, they understood the difficulties in maintaining tolerances and also quality. The operating procedure of this system is effortless, so any person can operate it. By using more techniques, they can be modified and developed per the applications. [2-4][6]

Analysis of tractor trolley chassis is done for different loading conditions such as when tractor trolley is traveling on speed brakes, while parking the trolley i.e., braking load condition and while taking left or right turn of trolley i.e., transverse loading condition. The chassis is the structural unit and it is one of the main parts of the tractor-trolley. It is the most decisive element that gives stability and strength under different load conditions of the vehicle. Many things are considered while designing a chassis such as weight, material selection, the strength of the material, and other material properties. It is the main mounting part for all the components including the body so it is also called the carrying unit. [8]

Stress analysis of an actual Tractor trolley chassis structure consisting of C section beams design application of 6 ton has been calculated in this paper. While putting light on the chassis, it states that it is one of the key components of the vehicle. A chassis consists of an internal framework that supports the container of the tractor trolley in its construction and use. It is a dead vehicle which is connected to the tractor to carry the load. Summarizing, it gave the information of the tractor trolley, tractor trolley chassis, SFD, BMD, deflection and stress analysis. [1-2][9]

Investigations were carried out to determine the causal factors, the activities involved and severity of injuries for farming and non-farming activities in tractor related accidents. A total of 76 cases involving five fatalities and 71 non-fatal injuries were recorded. The pattern of tractor related injuries in India have been found to be very different compared to those reported from highly industrialized countries. Fifty-four percent of tractor related injuries in the first phase and 49% in the second phase were because of non-farming activities. Of the total injuries recorded in both the phases only 1 and 6% were tractor related. A major cause of tractor related injuries were collisions. In the two phases 28 and 40% injured were passengers on tractor or trailer. [10]

2.1 Abbreviations and Acronyms

MEMS- Micro-electromechanical systems,
SFD- Shear Force Diagram,
BMD- Bending Moment Diagram

2. Objectives

The proposed system deals with mainly three objectives. One of the objectives being to prevent causalities happening with the trolley carrying heavy loads using automated hydraulic system, Another being to inform the driver about the tilting or shift of centre of gravity of the trolley, and last to reduce the probability of product loss and life threatening incidents.

3. Methodology

The proposed system is built by using Double-acting hydraulic cylinders that can pump hydraulic fluid to both sides of the plunger. There are two hydraulic cylinders used in the system, both are installed at the central transverse line of the trolley. They install vertically to the ground and have a difference of distance of 1.23 m. The hydraulic power is supplied by fluid present in the fluid tank with the help of a motor. Also, we had to use an accelerometer sensor to measure the slope of tilt occurring in the trolley under some distractive actions. Also, for sending alert signals to the driver.

The working system is auto-automatic when the tractor takes a sudden turn or passes from an uneven surface. At that time a sudden jerk developed in the trolley and it gets deflected from its design position. Because of that, the deflection gets on increases which may cause the rollover of the trolley. So, when the trolley gets on deflecting that develops the slope, and that slope is measured by the accelerometer sensor. This sensor sends signal to Arduino and that Arduino also has the programming for transferring and indicating the position of the trolley to the driver by using an LCD.

When the trolley crosses the provided limit then the hydraulic gets started automatically by a kinematic mechanism that installs to run the handle. As the handle gets activated the fluid starts to flow toward the piston head for applying the pressure. That pressure helps to expand the hydraulic system which further pushed up the trolley to gain its original position. After reaching the original position, the handle automatically causes reverse action, which again restores the original position of the hydraulic system. Similarly happens for the other side tilt, so this is how we can protect our trolley, material, and the life of the driver and neighboring drivers.

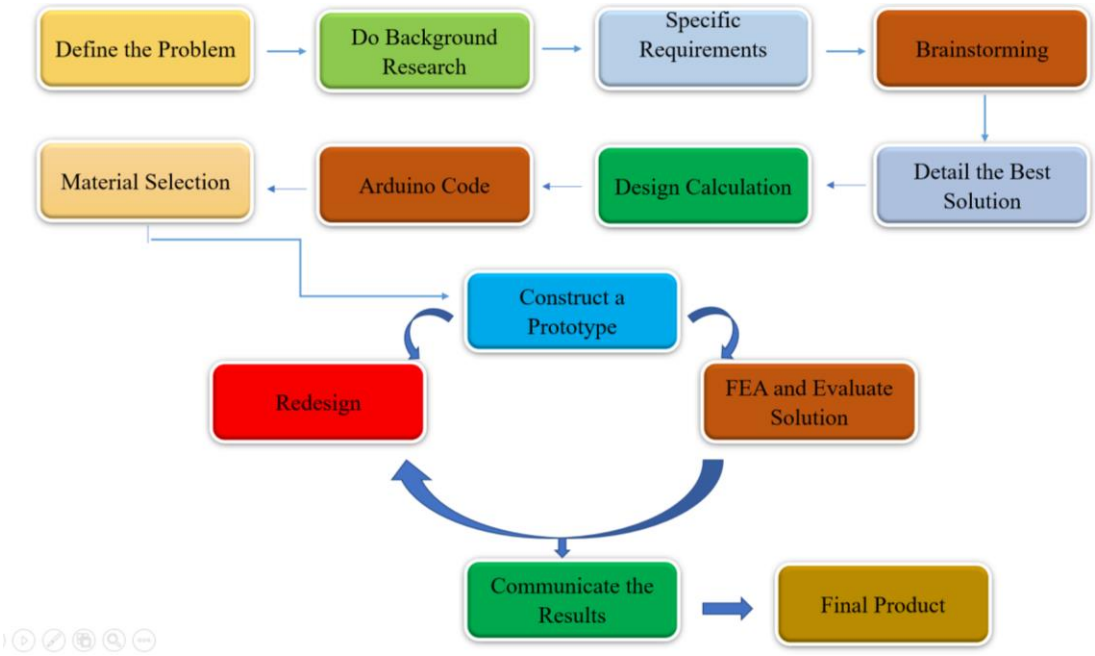

Figure 2 Flow Diagram for Process

4. Calculations

a) Calculations for deflected distance:

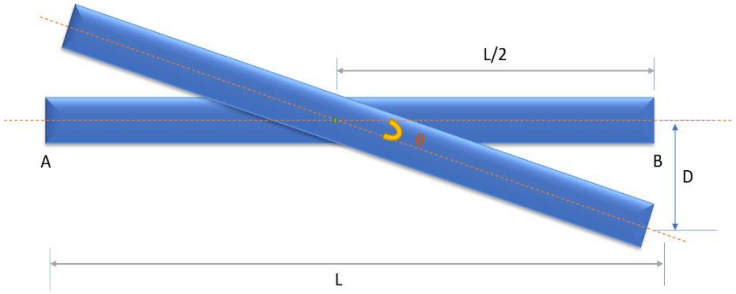

Figure 3 Deviation in trolley

L = Trolley width = 1.83m

D = Deflected distance θ = Slope

By Trigonometric Ratio Theorem:

$\tan\theta = D/(L/2)$

$D = L \tan\theta/2$

In this case we are designing for maximum tilt angle $\theta = 25°$

$D = (1.83*\tan25°)/2$

D = 0.4267 m

b) Calculations for Forces Developed on Piston:

Load (W) = 6 ton

Operating Pressure = 25MPa

Piston Diameter = 4 cm (40mm)

Piston Cross-section Area = 1256.63 mm^2

∴ We Know,

$P = F/A$

… Where F is maximum force resist by hydraulic system.

∴ $F = P*A$

$F = (25 * 1256.63)$

F = 31415.75 N

c) Calculations for Reaction Forces on Trolley:

At Steady State:

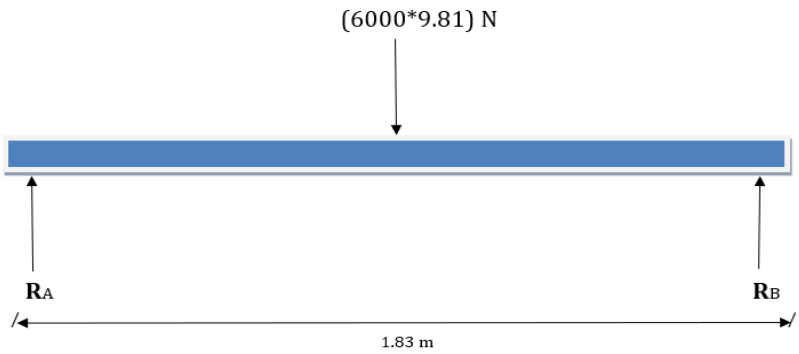

Figure 4 Trolley at Steady State

At Maximum Tilt State:

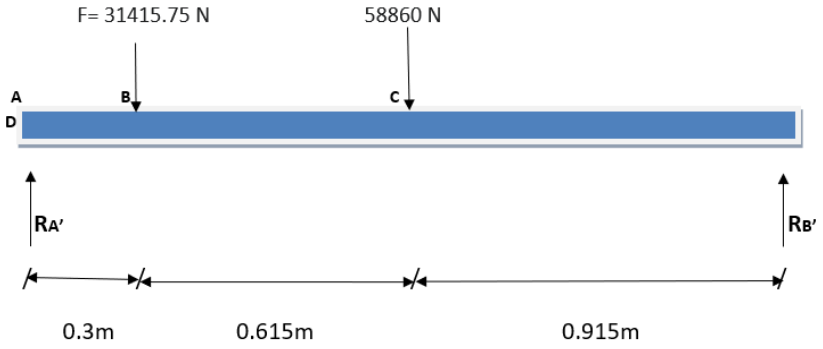

Figure 5 Trolley at Maximum Tilt State

$$\therefore F + 58860 = RA' + RB' \quad \text{_____ (1)}$$

Now,

$$\sum MA = 0$$

$$\therefore F * 0.3 + (58860 * 0.915) - (RB' * 1.83) = 0 \quad \text{_____ (2)}$$

RB' = 34580.122 N

From (1)

$$31415.75 + 58860 = RA' + 34580.122$$

RA' = 55695.628 N

d) Calculations for Shear Force on Trolley:

FA1 = 0 , FA2 = 55.6KN

FB1 = 55.6KN , FB2 = 24.27KN

FC1 = 24.27KN , FC2 = -34.58KN

FD1 = -34.58KN , FD2 = 0

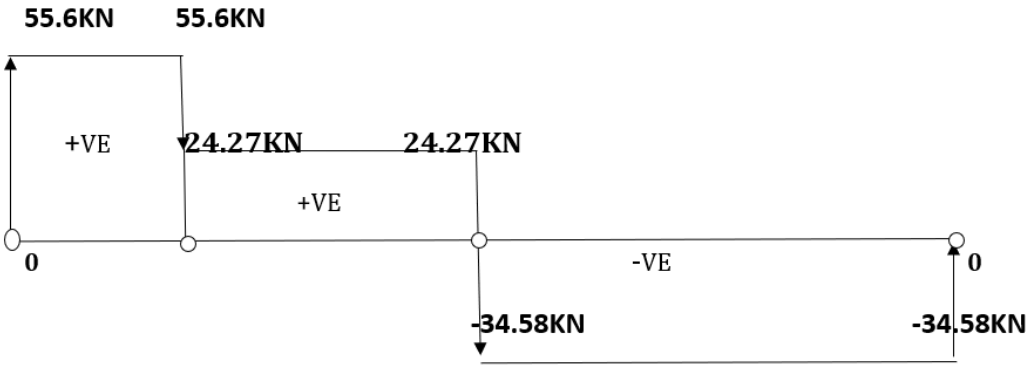

Figure 6 Line Diagram for Force Calculations

e) Calculations for Bending Moment on Trolley

MA = 0

MB = (55695.628 * 0.3) => 16708.68

MC = (55695.628 * 0.915) – (31415.75 * 0.615) => 31640.81

MD = 0

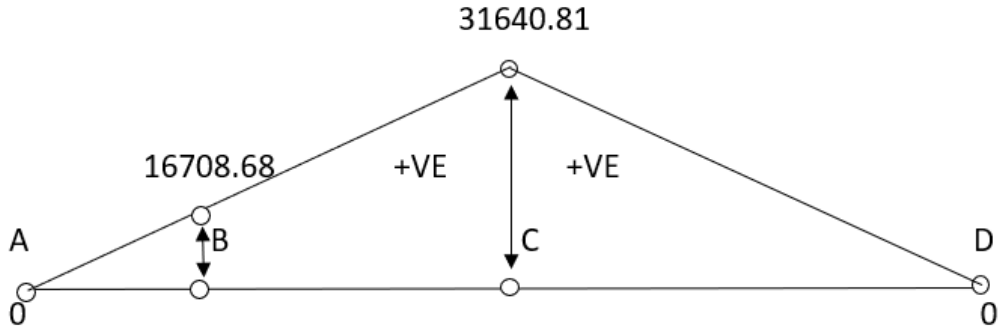

Figure 7 Line Diagram for Bending Moment

5. Cad Model Design

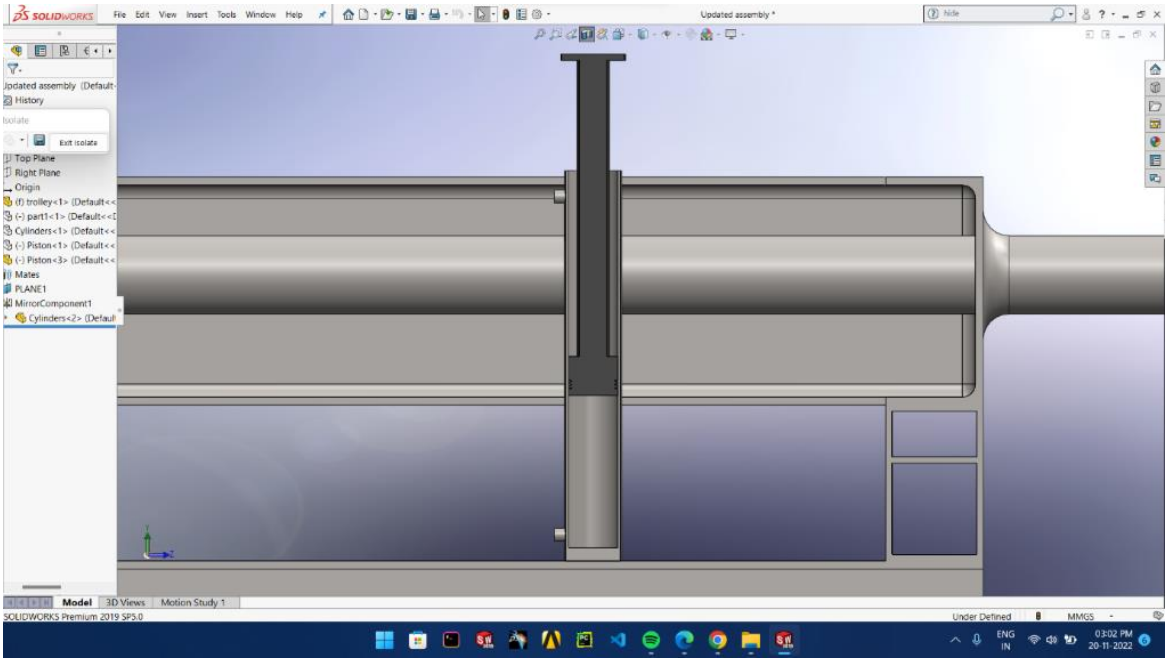

Figure 8 Section View of Cylinder

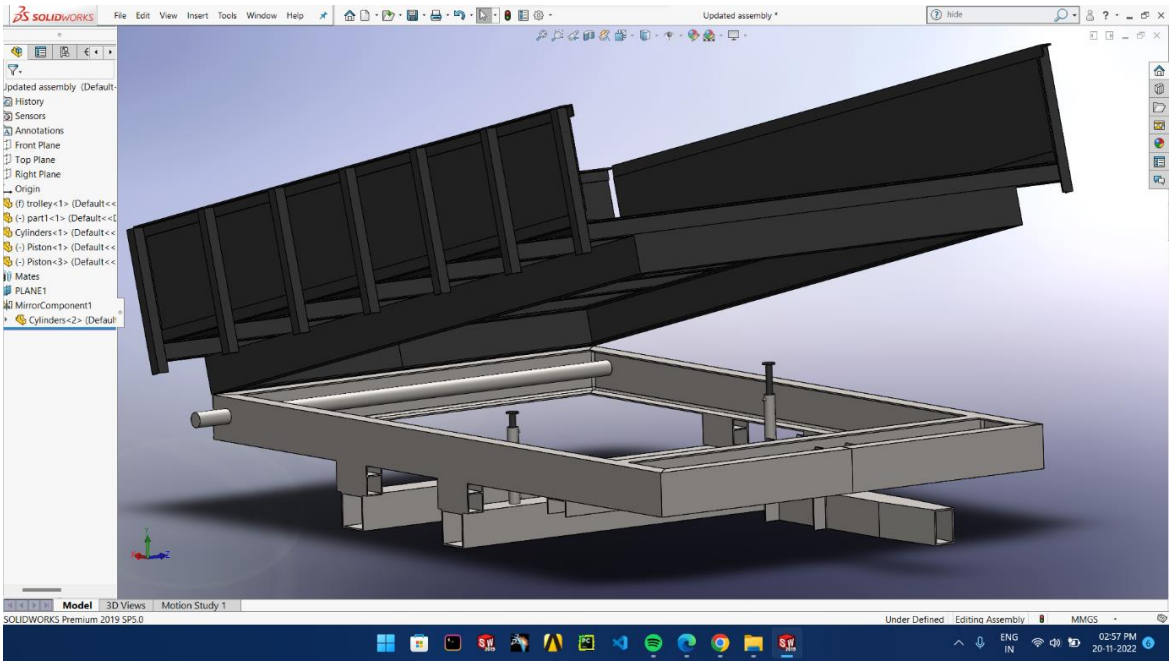

Figure 9 Isometric View of Trolley

6. Circuit

Simulation is carried out in a software called “TinkerCad”.

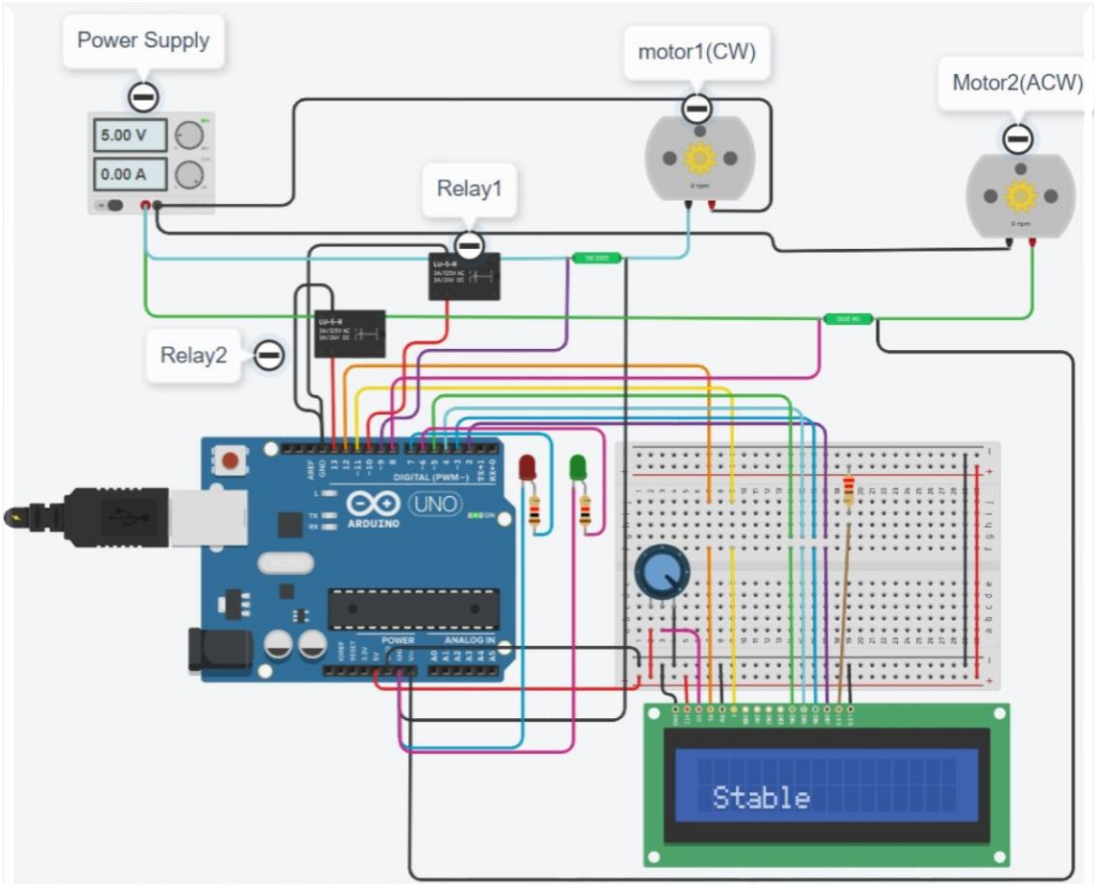

Figure 10 Circuit Diagram of the Automation System

Expected Outcomes

This project will help to reduce the accidents and casualties happening during transportation of agricultural goods to industries. System will be capable of alerting the driver about tilting of the trolley beyond threshold value. So it will bring the transformational change in the agricultural industry.

3. Future Scope

This system can be advanced using various laws of physics. Same system can be also installed in different heavy loaded vehicles which are used for transportation. We are also trying to design a system which will utilize the weight of trolley to bring the trolley in stable condition by eliminating the external energy (motors). We will be making system easy for installation.

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