A PROJECT REPORT

ON

"SELF BALANCING STRETCHER BED"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. GAZI ALTAMASH

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2020 -2021

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examinar (Prof.______)

External Examiner (Prof.____)

Head of Department (Prof. _____)

Principal (Dr._______)

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

___________________ ___________________

Date: ___________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. Gazi Altamsh** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof. Zakir Ansari** , Head Of Department, **Prof. Yusuf** , Project Co-Guide and Prof. , Project co-ordinator from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

I am thankful to **Prof. Zakir Ansari**, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

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TABLE OF CONTENTS

ABSTRACT

This project presents a development of self-balancing platform mechanism using ATMEGA microcontroller. The platform has been designed using Stabilizing mechanism including Inertial measurement unit (IMU) and two servo, and controlled by an open source microcontroller. In this project the ATMEGA-328 microcontroller, servos, and a three-degree of freedom (axis) accelerometer have been used to create the controlled platform. The controller has been designed to maintain the platform at an initially selected angle when the support structure orientation changes. The software has been written with logic to convert the digital data with the help of MPU6050 . The magnitude is then compared to a predetermined. Mathematical function to infer the angle of tilt of the platform. The angle of tilt is then converted to angle of rotation for the servos to act on.

CHAPTER 1
INTRODUCTION

According to the National Ambulatory Model Care Survey (NAMCS) 2017, comfort of the person transmitting through the ambulance is very crucial. Ambulance service is to transport the patient from the accident site to the hospital as quickly as possible. It is not an easy procedure to comfortably transport patient in the ambulance .Since the patient is already injured and the difficulties to treat the patient in the moving ambulance, the role of improving the existing emergency medical services is crucial. The risks and injuries are generated from potentially dangerous shocks and different motion transmitted through the ambulance as it transmit over the uneven road surface .The vibration produced in ambulance can lead to a secondary injury to the patient and discourage a parametric from providing emergency care .Now days in a common procedure to strap the patient to the stretcher and transport in the ambulance. But it will not effectively reduce the uneven motions that are transmitted. The aim of our project is to study about the uneven motion and vibration experienced by a patient on the stretcher in a moving ambulance and to develop a new model or mechanism that would potentially reduce the most harmful uneven motion transmitted through the current ambulance on un even road.

1.1) BACKGROUND

Today many industries are dependent on stabilizing mechanisms. The technique is used in a wide range of products, from camera stabilizing devices (Gosselin, St-Pierre, 2003) to helicopters (Institute fur Theoretische Elektrotechnik und Systemoptimierung, 2006) and medical devices when performing precise surgery (Journal of Cardiothoracic and Vascular Anesthesia, 2002, 685–690). One field of application is the stabilizing platform, which for example is used in self-leveling equipment like anti-motion sickness chairs (David E. Grober, US 7490572 B2). The stabilizing platform, which purpose is to compensate for angular fluctuation, exists in many forms. The idea is to measure the angle which the platform is tilted, and then compensate for this by a motor. The angle can be measured by a potentiometer or by more advanced sensors, and the motors can be anything from servo motors to step motors and DC-motors (Liu, Qiang Zhu and Howe, 2006).

1.2) PROBLEM STATEMENT

- Due to increasing population and accidents on roads sometimes doctors are bound to perform minor medical procedures/operations in the moving vehicle like AMBULANCE, SHIP and PLANE.
- Ambulance, travels on roads which are man-made and are usually flat and smooth. But in some developing countries, like India, conditions of roads are dangerous.
- The roads also fail to provide stability due to number of pits, speed breakers and other such factors, which cause sudden jerks. Because of this keeping patient stable during medical procedures is a big issue.

1.3) OBJECTIVE:

1) We can carry a very heavily injured person from accident place to hospital without giving him any harm.
2) It can be used in various fields such as, military, medical etc.
3) It can be very useful in rural areas.
4) We can give less shock to patient on bad roads

CHAPTER 2

LITERATURE REVIEW:-

1) Anders Karlsson& Jonathan Caressel In the year of 2016 they have developed a report to analyze how a common PID controller will react to variations in load. This report will describe the construction and development of a self stabilizing platform, controlled by two PID controllers based on the Arduino platform.

2) Shalaka Turalkar He prepared a paper which presents a development of self-stabilizing platform mechanism using ATMEGA microcontroller in the year 2017.This paper is also useful to analyze how close loop systems can be used along with accelerometers and gyroscope sensors to stabilize the platform.

3) Dean Kamen The United states began regulating self balancing platform in 2002,just after the product began to be marketted and a year after a media campaign promoting the self balancing platform and its inventor Dean Kamen.

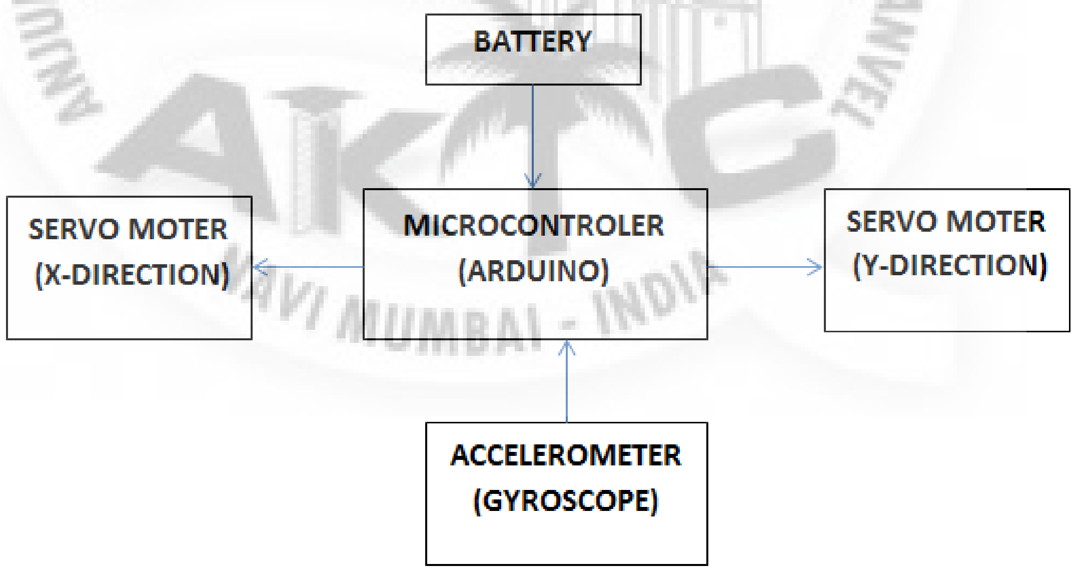
4) Kealeboga Mokonopi In the year of 2006 this project draws on the theoretical principles of the equally popular experiment of the inverted pendulam the inverted pendulamunlike many other controls system is naturally unstable the system therfore has to be controlledto reach the stability in this unstable state.

CHAPTER 3

METHODOLOGY

- The Ambulance will provide with platform on which the patient will be loaded. The platform will be self-stabilize.
- To stabilize the platform will be using gyroscopic sensor and servomotor.
- Gyroscopic sensor used to measure the acceleration of a moving or vibrating body and can sense X, Y direction and tilt angle and gives signal to the microcontroller.
- If the Ambulance is on the uneven or rough road then the movement or vibration is sensed is sensed by the accelerometer and it gives signal to the microcontroller, then microcontroller controls the motion of servomotor according to X,Y direction and tilt angle.
- If the Ambulance is tilted on left side then with the help of servomotor the platform will be tilted on right side to keep the platform horizontal.

3.1) BLOCK DIAGRAM:

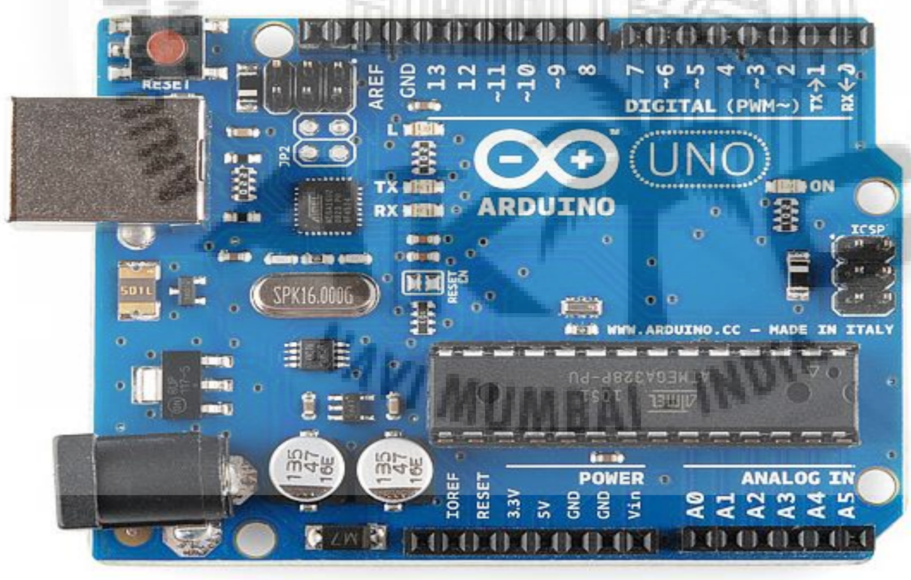


3.2) Electronic Components:

3.2.1) ARDUINO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board -- you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.



3.2.2) ATmega328

ATmega328 is an eight (8) bit Microcontroller. It can handle the data sized of up to eight (8) bits. It is an AVR based micro-controller. Its built-in internal memory is around 32KB. It operates ranging from 3.3V to 5V. It has an ability to store the data even when the electrical supply is removed from its biasing terminals. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, real timer counter with separate oscillator. It’s normally used in Embedded Systems applications. You should have a look at these Real Life Examples of Embedded Systems, we can design all of them using this Microcontroller. ATmega-328 is shown in the figure given below.

3.2.2.1) ATmega 328 pins

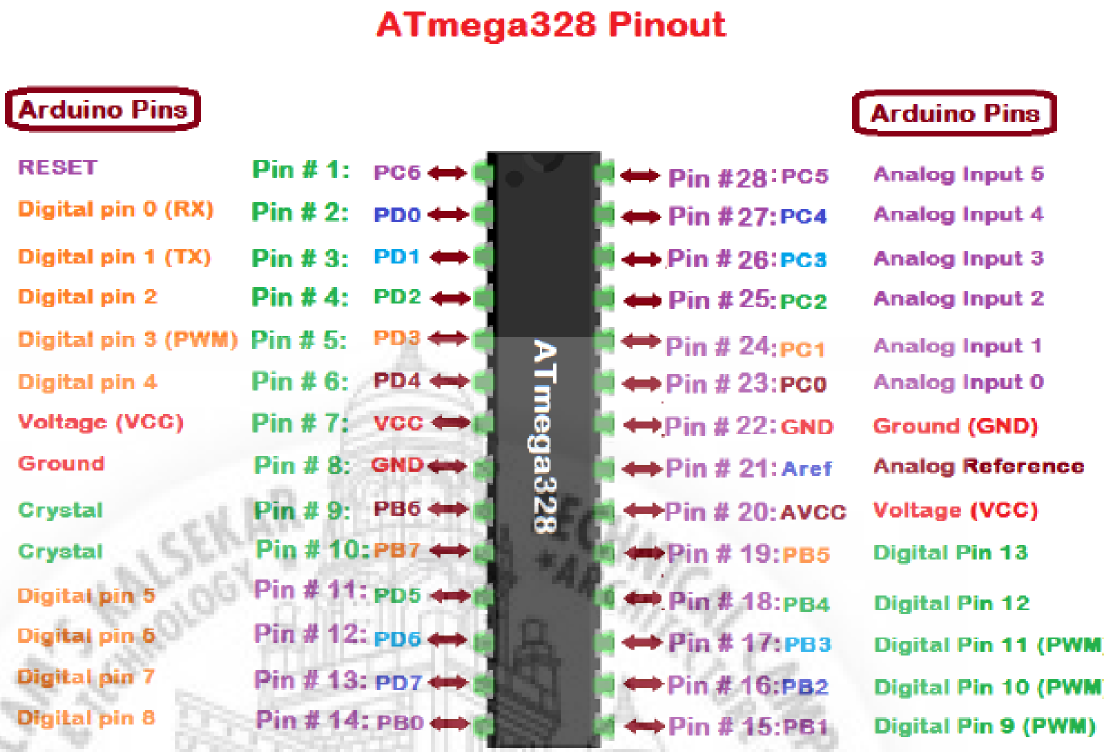
1. ATmega-328 is an AVR Microcontroller having twenty eight (28) pins in total.
2. All of the pins in chronological order, are listed in the table shown in the figure given below.

ATmega328 Pins			
Pin Number	**Pin Name**	**Pin Number**	**Pin Name**
1	PC6	15	PB1
2	PD0	16	PB2
3	PD1	17	PB3
4	PD2	18	PB4
5	PD3	19	PB5
6	PD4	20	AVCC
7	Vcc	21	AREF
8	GND	22	GND
9	PB6	23	PC0
10	PB7	24	PC1
11	PD5	25	PC2
12	PD6	26	PC3
13	PD7	27	PC4
14	PB0	28	PC5

3.2.2.2) ATmega 328 Pinout

1. Through pinout diagram we can understand the configurations of the pins of any electronic device, so you are working on any engineering project then you must first read the components' pinout.

2. ATmega 328 pinout diagram is shown in the figure given below.



ATmega 328 pins description

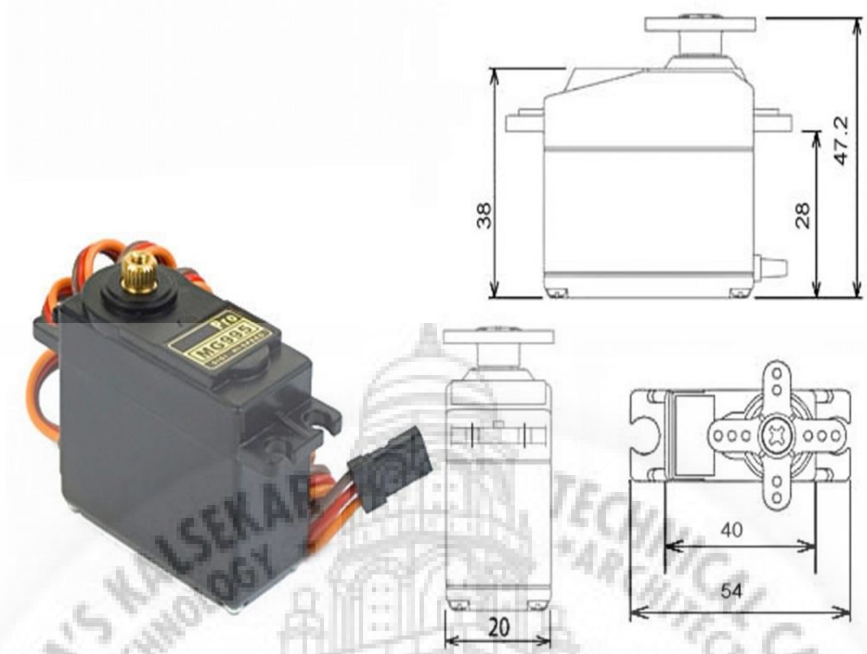
1. Functions associated with the pins must be known in order to use the device appropriately.
2. ATmega-328 pins are divided into different ports which are given in detail below.
3. VCC is a digital voltage supply.
4. AVCC is a supply voltage pin for analog to digital converter.
5. GND denotes Ground and it has a 0V.
6. Port A consists of the pins from PA0 to PA7. These pins serve as analog input to analog to digital converters. If analog to digital converter is not used, port A acts as an eight (8) bit bidirectional input/output port.
7. Port B consists of the pins from PB0 to PB7. This port is an 8 bit bidirectional port having an internal pull-up resistor.
8. Port C consists of the pins from PC0 to PC7. The output buffers of port C has symmetrical drive characteristics with source capability as well high sink.
9. Port D consists of the pins from PD0 to PD7. It is also an 8 bit input/output port having an internal pull-up resistor.
10. **All of the AVR ports are shown in the figure given below.**

1. AREF is an analog reference pin for analog to digital converter.
2. So this was the brief of all the pins in ATmega 328 AVR micro-controller.

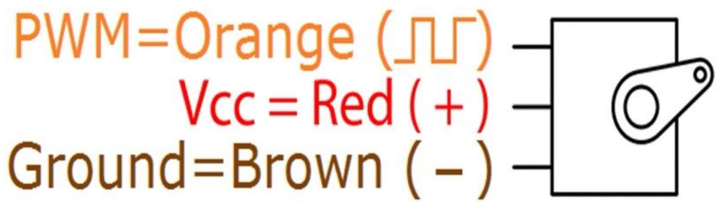
Applications

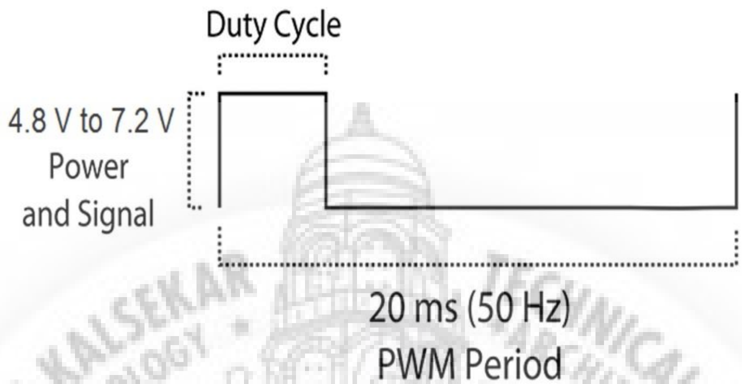
1. A complete package including ATmega 328 and Arduino can be used in several different real life applications.
2. It can be used in Embedded Systems Projects.
3. It can also be used in robotics.
4. Quad-copter and even small aero-plane can also be designed through it.
5. Power monitoring and management systems can also be prepared using this device.

3.2.3) MG995 HIGH SPEED SERVO MOTOR (Prototype)

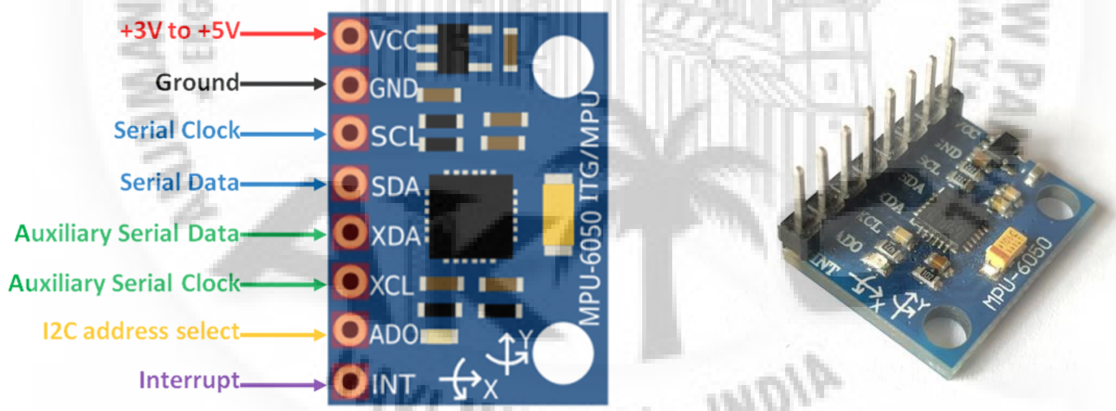


The unit comes complete with 30cm wire and 3 pin 'S' type female header connector that fits most receivers, including Futaba, JR, GWS, Cirrus, Blue Bird, Blue Arrow, Corona, Berg, Spectrum and Hitec. This high-speed standard servo can rotate approximately 120 degrees (60 in each direction). You can use any servo code, hardware or library to control these servos, so it's great for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. The MG995 Metal Gear Servo also comes with a selection of arms and hardware to get you set up nice and fast! Specifications • Weight: 55 g • Dimension: 40.7 x 19.7 x 42.9 mm approx. • Stall torque: 8.5 kgf·cm (4.8 V), 10 kgf·cm (6 V) • Operating speed: 0.2 s/60º (4.8 V), 0.16 s/60º (6 V) • Operating voltage: 4.8 V a 7.2 V • Dead band width: 5 µs • Stable and shock proof double ball bearing design • Temperature range: 0 ºC – 55 ºC





3.2.4) MPU6050 - Accelerometer and Gyroscope Module



3.2.4.2) MPU6050 Pin Configuration

PIN NAME	DESCRIPTION
VCC	Provides power for module, can be +3V or +5V. Typically +5V is used.
GROUND	Connected to the ground of system.
SERIAL CLOCK (SCL)	Used to provide clock pulse for 12c communication
SERIAL DATA (SDA)	Used for transferring data through 12c communication
AXILLARY SERIAL DATA (XDA)	Can be used to interface other I2C modules with MPU6050. It is optional
AUXILIARY SERIAL CLOCK (XCL)	Can be used to interface other I2C modules with MPU6050. It is optional
AD0	If more than one MPU6050 is used a single MCU, then this pin can be used to vary the address
INTERRUPT (INT)	Interrupt pin to indicate that data is available for MCU to read.

3.2.4.3) MPU6050 Features

1. MEMS 3-aixs accelerometer and 3-axis gyroscope values combined
2. Power Supply: 3-5V

3. Communication : I2C protocol
4. Built-in 16-bit ADC provides high accuracy
5. Built-in DMP provides high computational power Can be used to interface with other IIC devices like magnetometer
6. Configurable IIC Address
7. In-built Temperature sensor

3.2.4.4) Where to Use MPU6050

The MPU6050 is a Micro Electro-Mechanical Systems (MEMS) which consists of a 3-axis Accelerometer and 3-axis Gyroscope inside it. This helps us to measure acceleration, velocity, orientation, displacement and many other motion related parameter of a system or object. This module also has a (DMP) Digital Motion Processor inside it which is powerful enough to perform complex calculation and thus free up the work for Microcontroller.

The module also have two auxiliary pins which can be used to interface external IIC modules like an magnetometer, however it is optional. Since the IIC address of the module is configurable more than one MPU6050 sensor can be interfaced to a Microcontroller using the AD0 pin. This module also has well documented and revised libraries available hence it’s very easy to use with famous platforms like Arduino. So if you are looking for a sensor to control motion for your **RC Car, Drone, Self balancing Robot, Humanoid, Biped** or something like that then this sensor might be the right choice for you.

3.1.4.5) Applications

1. Used for IMU measurement
2. Drones / Quad copters
3. Self-balancing robots.
4. Robotic arm controls
5. Humanoid robots
6. Tilt sensor
7. Orientation / Rotation Detector

3.2.5) JUMP WIRE

A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

3.2.5.1) Types of jump wire

There are different types of jumper wires. Some have the same type of electrical connector at both ends, while others have different connectors. Some common connectors are:

Solid tips – are used to connect on/with a breadboard or female header connector. The arrangement of the elements and ease of insertion on a breadboard allows increasing the mounting density of both components and jump wires without fear of short-circuits. The jump wires vary in size and colour to distinguish the different working signals.

Crocodile clips – are used, among other applications, to temporarily bridge sensors, buttons and other elements of prototypes with components or equipment that have arbitrary connectors, wires, screw terminals, etc.

Banana connectors – are commonly used on test equipment for DC and low-frequency AC signals.

Registered jack (RJnn) – are commonly used in telephone (RJ11) and computer networking (RJ45).

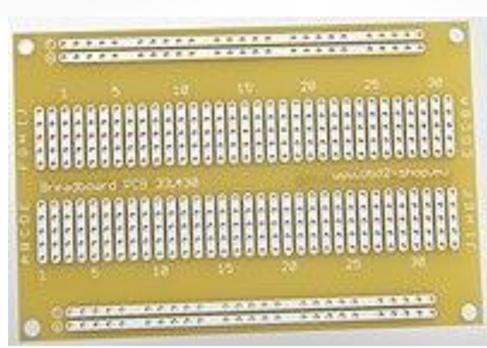
RCA connectors – are often used for audio, low-resolution composite video signals, or other low-frequency applications requiring a shielded cable.

RF connectors – are used to carry radio frequency signals between circuits, test equipment, and antennas.

RF jumper cables - Jumper cables is a smaller and more bendable corrugated cable which is used to connect antennas and other components to network cabling. Jumpers are also used in base stations to connect antennas to radio units. Usually the most bendable jumper cable diameter is 1/2".

3.2.6) BREADBOARD

A breadboard is a construction base for prototyping of electronics. Originally the word referred to a literal bread board, a polished piece of wood used for slicing bread.[1] In the 1970s the solderless breadboard (a.k.a. plugboard, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these.



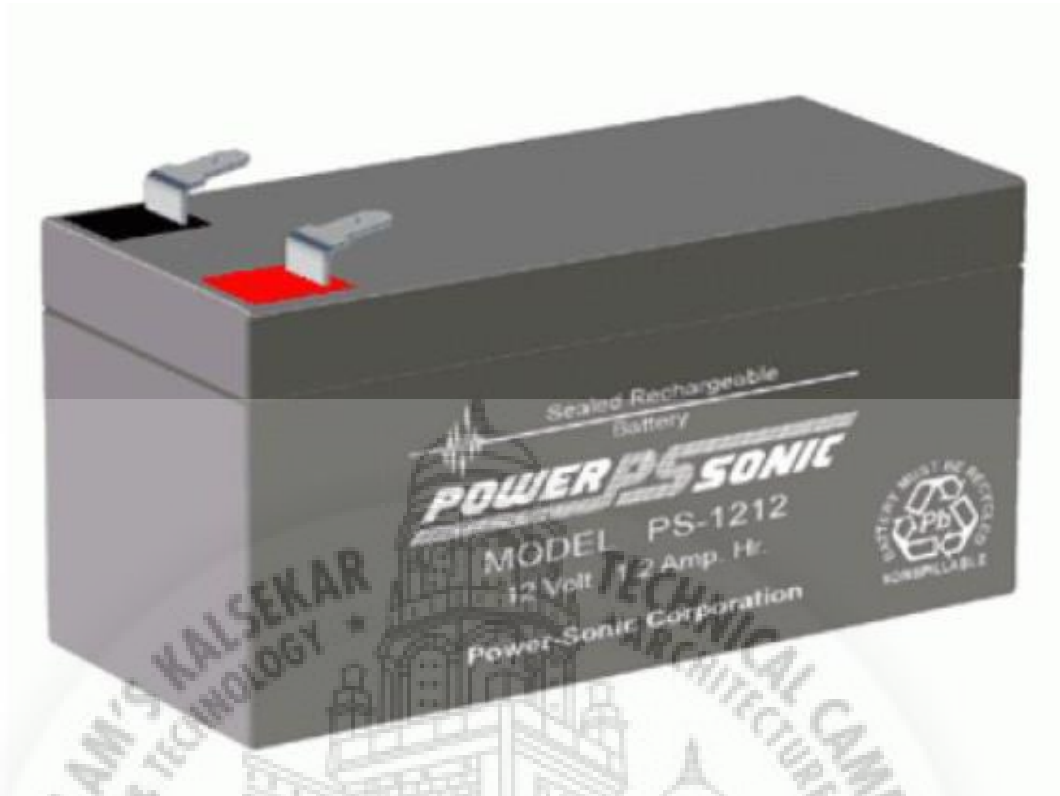
Electrical equivalent 400 point solderless breadboard

400 point printed circuit board (PCB) breadboard with 0.1 inches (2.54 mm) hole-to-hole spacing is electrically equivalent to the solderless breadboard shown above.

Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also popular with students and in technological education. Older breadboard types did not have this property. A stripboard (Veroboard) and similar prototyping printed circuit boards, which are used to build semi-permanent soldered prototypes or one-offs, cannot easily be reused. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

3.2.7) LEAD ACID BATTERY

This is a rechargeable 12volt 1.2AH Sealed Lead Acid Battery Our Power-Sonic or Equivalent valve regulated sealed lead acid batteries are maintenance free, easy to handle, rugged and economical. It has a characteristic of high discharge rate, wide operating temperature, long service life and deep discharge recover. This product has Absorbent Glass Mat (AGM) technology for superior performance. This product is valve regulated and spill proof construction allows safe operation in any position and the power/ volume ratio yields unrivaled energy density. This product is approved for transport by air.



3.2.7.1) FEATURES

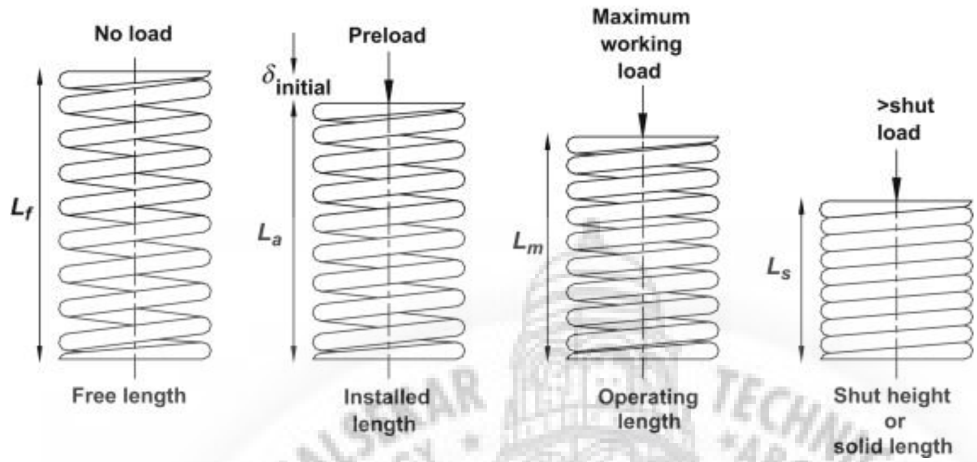
1. Battery Type: SLA (Sealed Lead Acid)
2. Voltage: 12 volts • AH Rating: 1.2 AH
3. Meets or Exceeds Original Battery Specifications
4. Non-spillable Valve Regulated Lead Acid (V.R.L.A.) Design.
5. Advanced absorbed glass mat technology
6. Sealed construction for operation in any position except upside down.
7. Wide operating temperature range.
8. High discharge rates and low self discharge rates.
9. Available in VO Flame Retardant Material.

3.2.8) SUPER 300 HIGH SERVO MOTOR (Real life)

1. Maximum torque: 200KG.CM / 300KG.CM (24V) (actual, non theoretical value)
2. Angular velocity: 0.5S/60 degrees (60 degrees 0.5S), 24V
3. The rotation angle: 300 degrees MAX, mean maximum stroke of 300 degrees (0 to 300 degrees adjustable electronic limit)
4. Power input: 12V-24V DC (V- connects with the cathode, V+ connect selectable operating modes, you can control the speed of servo speeds with the anode)

3.3) Calculation

3.3.1) Spring Design



Material = stainless steel

E= 200000 $N/_{mm^2}$

τ= 242.5 $N/_{mm^2}$

Weight = 150 kg

w= 1500 N

Spring index = 8

δ= 20mm

Stiffness of spring is given by

K= $\frac{W}{\delta}$ = $\frac{1500}{20}$ = 75 $N/_{mm}$

Spring index is given by

C = $\frac{D}{d}$

D = C × d ……….. (1)

Shear Stress Factor

$K_s = \frac{4c-1}{4c-4} + \frac{0.615}{c}$

$K_s = 1.184$

Resultant Shear Stress

$\tau = \frac{8wc}{\pi \times d^2} \times K_s$

$d^2 = \frac{8wc}{\pi \times \tau} \times K_s$

d = 12 mm

Putting d in equation (1)

D = 12 × 8

D = 96 mm

Number of turns in spring

$\delta = \frac{8 \times w \times n \times D^3}{E \times d^4}$

n = 7.8

For ground end and closed spring

n_1 = n + 2

= 8 + 2

n_1 = 10

Solid length of spring

$L_s = n_1 \times d$

$= 10 \times 12$

$L_s = 120$ mm

Free Length of spring

$L_f = L_s + \delta + 0.15 \times \delta$

$= 120 + 20 + 0.15 \times 20$

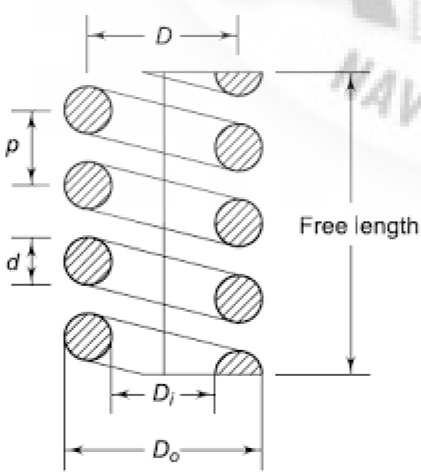
$L_f = 143$ mm

Pitch of spring

$P = \frac{free\ length}{n_1 - 1}$

$P = \frac{143}{9}$

P =15.88 mm



3.3.2) Gear Mechanism

1) Given

Z_1 = 21 Z_2 = 21 i = 1

T = 200 kg.cm

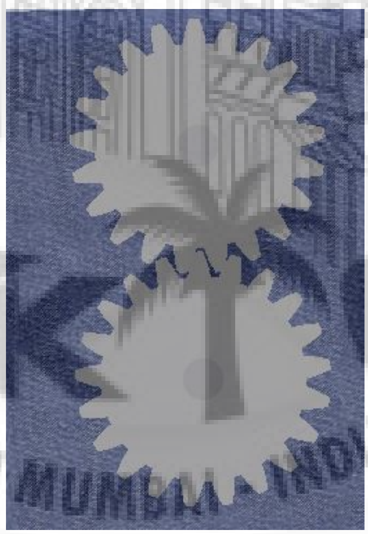
T = 19.6133 Nm

T = 19.6133 × 10^3 Nmm

P = 0.020 kw

$\propto$ = 20° full depth …………. (8.50)

2)Construction



3) Material Selection

C-45 [σ_b] = 140 Mpa [σ_c] = 500 Mpa …………… (8.5)

4) Calculation of module

$m \geq 1.26 \sqrt[3]{\frac{[M_t]}{Y[\sigma_b]\ \varphi Z}}$…………………(8.13A)

$[M_t]$ = T

$\Phi = \frac{b}{m}$ = 10 …………… (8.14)

Y = 0.326 ………………. (8.53) table 40

$m \geq 1.26 \sqrt[3]{\frac{[19.6133 \times 10^3}{0.326 \times 140 \times 10 \times 21}}$

m ≥ 2.57 m= 4

5) Checking for contact stress

$\sigma_c = 0.74 \times \frac{i+1}{a} \sqrt{\frac{i \mp 1 E_1\ [M_t]}{i\ b}}$ …………….(8.13)

$a = m \frac{Z_1 + Z_1}{2} = 4 \times \frac{21+21}{2} = 84$…………..(8.22)

$b = \varphi \times m = 10 \times 4 = 40$ mm

$E = 2.15 \times 10^5$ Mpa …………….(8.14)

$\sigma_c = 0.74 \times \frac{1+1}{84} \sqrt{\frac{1+1 \times 2.15 \times 10^5 \times 19.6133 \times 10^3}{1 \times 40}}$

$\sigma_c = 255.83 \leq [\sigma_c]$

Design is safe

6) Checking for static and dynamic load (F_s, F_d)

$F_s \geq F_d$ ………… (8.51)

$F_s = [\sigma_b] \times \text{b} \times \text{Y} \times \text{m}$

$= 140 \times 40 \times 0.326 \times 4$

F_s = 7302.4 N

$F_d = F_t \times C_v$

$F_t = \frac{[P]}{V_m}$

$[P]$ = P × S.F = 0.020 × 1.2 ………… (7.69)

$[P]$ = 0.024 Kw

$V_m = \frac{\pi DN}{60}$ P = $\frac{2 \times \pi \times N \times T}{60}$

$V_m = \frac{\pi \times m \times Z_1 \times N}{60}$ 0.020 = $\frac{2 \times \pi \times N \times 19.613}{60}$

$V_m = \frac{\pi \times 4 \times 21 \times 10}{60}$ N = 10 rpm

V_m = 0.043 $^m/_s$

$F_t = \frac{[P]}{V_m} = \frac{0.024 \times 10^3}{0.043}$

F_t = 558.13 N

$C_v = (\frac{3+V_m}{3}) = \frac{3 + 0.043}{3}$

C_v = 1.01

$F_d = F_t \times C_v$ = 558.13 × 1.01

F_d = 563.71 N

$F_s \geq F_d$

Design is safe

7) Checking for wear load

$F_w \geq F_d$

$F_w = d_1 Q\ k\ b$

$d_1 = m \times z = 4 \times 21 = 84$ mm

$Q = \frac{2 \times i}{i+1} = \frac{2 \times 1}{1+1} = \frac{2}{2} = 1$

$K = \frac{[\sigma_c]^2 \ sin\alpha \ [\frac{1}{E_1} + \frac{1}{E_2}]}{1.4}$

$= \frac{[500]^2 \ sin20 \ [\frac{1}{2.15 \times 10^5} + \frac{1}{2.15 \times 10^5}]}{1.4}$

K = 0.568

$b = \varphi \times m = 10 \times 4 = 40$ mm

$F_w = d_1 Q\ k\ b$

$F_w = 84 \times 1 \times 0.568 \times 40$

$F_w = 1908.48$ N

$F_w \geq F_d$

Design is safe

8) Design of shaft

Material: C-45

$\sigma_y = 360$ Mpa

F.O.S = 4

$\sigma_b = \sigma_t = \sigma_c$ = 90 Mpa

$\tau = 45$ Mpa

B.M = $F_t \times$ l

B.M = 558.13 × 200

B.M = 111626 Nmm

$T_{req} = \sqrt{M^2 + T^2}$

$= \sqrt{(111626)^2 + (19.613 \times 10^3)^2}$

$T_{req} = 113.33 \times 10^3$

$T_{req} = \frac{\pi}{16} \times \tau \times d_s^3$

$113.33 \times 10^3 = \frac{\pi}{16} \times 45 \times d_s^3$

d_s = 23 mm

d_s = 30 mm

9) Principal dimension ………… (8.22)

Nomenclature	Pinion	Wheel
Module (m)	4 mm	4 mm
Centre distance (a)	84	84
No. of teeth (Z)	21	21

3.3.3) Design of connecting Rod

Step 1) selection of Material

C-50

σ_{yt} = 380 Mpa   F.O.S = 4 …………… (1.9)

$\sigma_b = \sigma_t = \sigma_c = \frac{\sigma_{yt}}{\text{F.O.S}} = \frac{380}{4}$ = 95 Mpa

$\sigma_s = \tau = 0.5\,\sigma_t = 0.5 \times 95$

$\sigma_s = \tau$ = 47.5 Mpa

$\sigma_b = 1.5\,\sigma_t = 1.5 \times 95$

σ_b = 142.5 Mpa

P = 200 Kg

P = 1962 N

Step 2) Design connecting Rod

A) Rod

i) Tensile

$\sigma_t = \frac{p}{\frac{\pi}{4} \times d^2}$

$95 = \frac{1962}{\frac{\pi}{4} \times d^2}$

d = 5.12 mm

Selected d = 30 mm

B) Pin

i) Shear

$\sigma_s = \frac{p}{\frac{\pi}{4} \times d_1^2}$

$47.5 = \frac{1962}{\frac{\pi}{4} \times d_1^2}$

d_1= 5.12 mm

d_1= 15 mm

ii) Crushing in Single eye

$\sigma_c = \frac{P}{d_1 \times t} = \frac{1962}{15 \times t}$ = 1.37 mm

t = 10 mm

iii) Crushing in Double eye

$\sigma_c = \frac{P}{2 \times d_1 \times t_1} = \frac{1962}{2 \times 15 \times t_1}$

t_1 = 0.6884 mm

t_1 = 5 mm

iv) Bending

$\sigma_{bend} = \frac{\frac{P}{2}[\frac{t_1}{3} + \frac{t}{4}]}{\frac{\pi}{32} \times d_1^3}$

$\sigma_{bend} = \frac{\frac{1962}{2}[\frac{5}{3} + \frac{10}{4}]}{\frac{\pi}{32} \times 15^3}$

σ_{bend} = 12.33 Mpa $< \sigma_b$

Design is safe

C) Single eye

i) Tensile stress

$\sigma_t = \frac{P}{(d_2 - d_1)t}$

$95 = \frac{1962}{(d_2 - 15) \times 10}$

d_2 = 17.06 mm

d_2 = 25 mm

ii) Shear

$\sigma_{shear} = \frac{P}{(d_2 - d_1)t}$

$\sigma_{shear} = \frac{1962}{(25 - 15)10}$

σ_{shear} = 19.62 Mpa $< \sigma_s$

Design is safe

D) Double eye

i) $\sigma_t = \frac{P}{2 \times (d_2 - d_1) \times t_1}$

$\sigma_t = \frac{1962}{2 \times (25 - 15) \times 5}$

σ_t= 19.62 < σ_t Mpa

Design is safe

ii) $\sigma_s = \frac{P}{2 \times (d_2 - d_1) \times t_1}$

$\sigma_s = \frac{1962}{2 \times (25 - 15) \times 5}$

σ_s = 19.62 Mpa < σ_s

Design is safe

E) Collar

d_3 = 1.5 × d_1 = 1.5 × 15 =22.5 mm

d_3 = 25 mm

3.3.4) Design of bearing

Given

F_r = 50 Kg = 50 × 9.81 = 490.5 N

F_r = 500 N

F_a = 200 Kg = 200 × 9.81 = 1962 N

F_a = 1962 N

L_{90} = 24 × 3 × 365 (1 day hars × 3 years × 1 year day)

$(L_{90})_{hrs}$ = 26280

N = 5 rpm

d = 25 mm

Step 1)

SKF	Diameter (d)	C	$C_{\circ}$	P.S.G
6005	25	780	520	4.12
6205	25	400	710	4.13
6305	25	1660	1040	4.14
6405	25	2825	2000	4.15

Step 2) Design

1) Calculate equivalent Load (P_e)

P_e = (X V F_r + Y F_a) S_{kt}

V = 1.2 ………… (Both races rotating)

S = 1.3 ………. (4.2)

K_t = 1.05 …….. (4.2)

Assuming pure radial bearing

F_a = 0

P_e = (X V F_r + Y F_a) S_{kt} X = 1, Y = 0 …… (4.4)

P_e = (1× 1.2 × 500) × 1.3 × 1.05

P_e = 81.9 Kgf

2) Calculate (L_{90})

$(L_{90}) = \frac{60 \times N \times (L_{90})_{hrs}}{10^6}$

$(L_{90}) = \frac{60 \times 5 \times 26280}{10^6}$

(L_{90}) = 7.884

3) Dynamic load on bearing

$C = (\frac{L_{90}}{(L_{10}})^{\frac{1}{K}} \times P_e$ ………… (4.2)

$C = (7.88)^{\frac{1}{3}} \times 81.9$

C = 163 Kgf

Selecting the DGBB Bearing From (Step 1)

SKF 6005 d = 25 mm C = 780 $C_{\circ}$ = 520 ………… (4.12)

i) $\frac{F_a}{C_{\circ}} = \frac{196.2}{520} = 0.37$ ϵ =0.40

ii) $\frac{F_a}{F_r} = \frac{196.2}{50} = 3.924$

$\frac{F_a}{F_r} > \epsilon$

X = 0.56 , Y = 1.104

$P_e = (0.56 \times 1.2 \times 50 + 1.104 \times 196.2) \times 1.3 \times 1.05$

P_e = 341.52

$C = (L_{90})^{\frac{1}{3}} \times P_e$

$780 = (L_{90})^{\frac{1}{3}} \times 341.52$

$(L_{90}) = 11.9133$

3.3.5) Design Bed & Base

M = W × L = 1962 × 800

$M = 1569.60 \times 10^3$ Nmm

$\sigma_b = \frac{1569.60 \times 10^3 \times 6}{5 \times 40^2}$

σ_b = 11772 Mpa

Three plate are arranged in parallel

$\frac{200}{3}$ = 66.67 $\approx 100\ kg = 981\ N$

$\sigma_b = \frac{W \times L \times 6}{b \times h^2} = \frac{981 \times 800 \times 6}{5 \times 40^2}$

σ_b = 588.6 Mpa

If arranged 5 plate parallel

$\sigma_b = \frac{W \times L \times 6}{b \times h^2} = \frac{588.6 \times 800 \times 6}{5 \times 40^2}$

σ_b = 353.16 Mpa

If arranged 6 plate parallel

$\sigma_b = \frac{W \times L \times 6}{b \times h^2} = \frac{400 \times 800 \times 6}{5 \times 40^2}$

σ_b = 240 Mpa

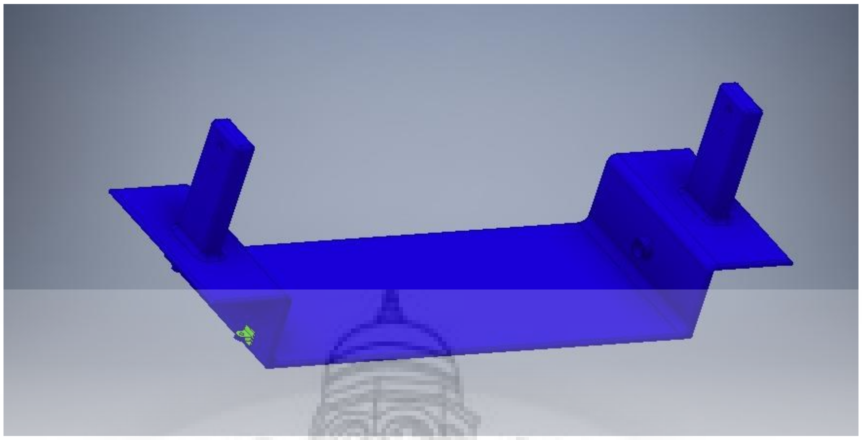
3.4) Modeling on Autodesk

Putting the ideas on the modeling software for visualization of the prototype and making it more and more compatible so that there will be less complexity in designing.

3.4.1) Material Selection

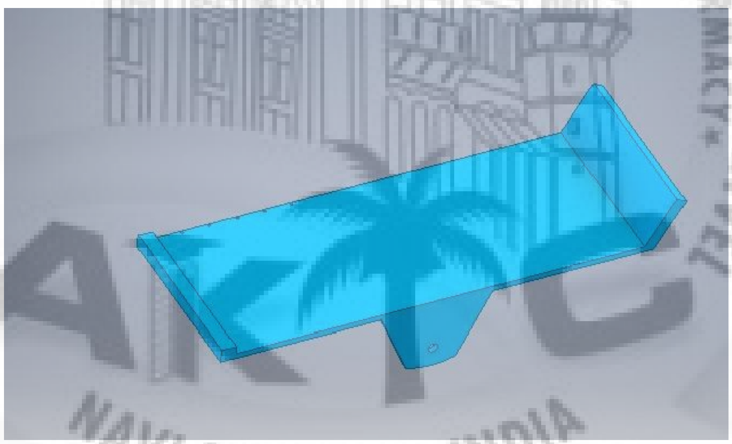
SR NO	PARTS	ORIGINAL MATERIAL	PROTYPE MATERIAL	QUENTITY
1	Base	Aluminium	Wood	1
2	Bed	Aluminium	Wood	1
3	Rolling Control	Aluminium	Wood	1
4	Connecting Rod 1	Mild Steel	Mild Steel	2
5	Connecting Rod 2	Mild Steel	Mild Steel	4
6	CR 1 Linkage 1	Stainless Steel	Wood	2
7	CR 1 Linkage 2	Stainless Steel	Wood	2
8	CR 2 linkage 1	Stainless Steel	Wood	4
9	CR 2 Linkage 2	Stainless Steel	Wood	4
10	Base Shaft	Stainless Steel	Mild Steel	1
11	Suspension Shaft	Stainless Steel	Mild Steel	4
12	Axle Shaft	Stainless Steel	Mild Steel	1
13	Tyre Support	Steel	Wood	4
14	C Type Tyre Support	Steel	Wood	4
15	Tyre			4

3.4.2) Base:



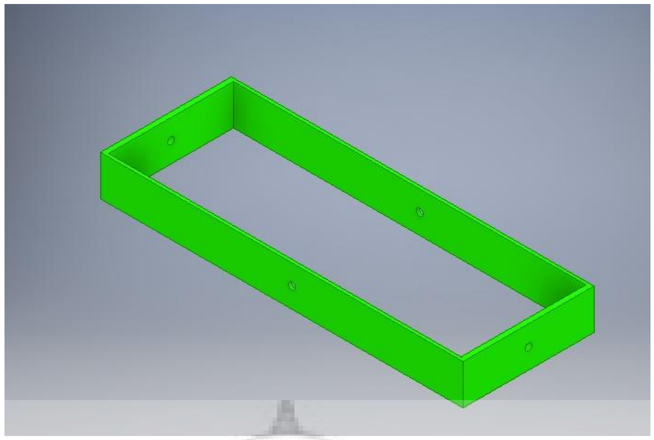
It is part that holds all component in this assembly it will provide rigid structure to rolling part and Bed. It has shaft that connected to a bearing so it easily rotate and provide motion in X and Y direction.

3.4.3) BED



It is a part where patients hold for treatment, bed is connected with base by three points two links support bed and one point rotate bed by sum angle as sensor given signal to Arduino and Arduino give signal to servo motor it will rotate bed as required angle.

3.4.4) Rolling part:



It is part that rotate in Y- direction along with Bed it will connect with two point support that come from Base and also hold Bed for motion.

3.4.5) Connecting Rod (Cr):

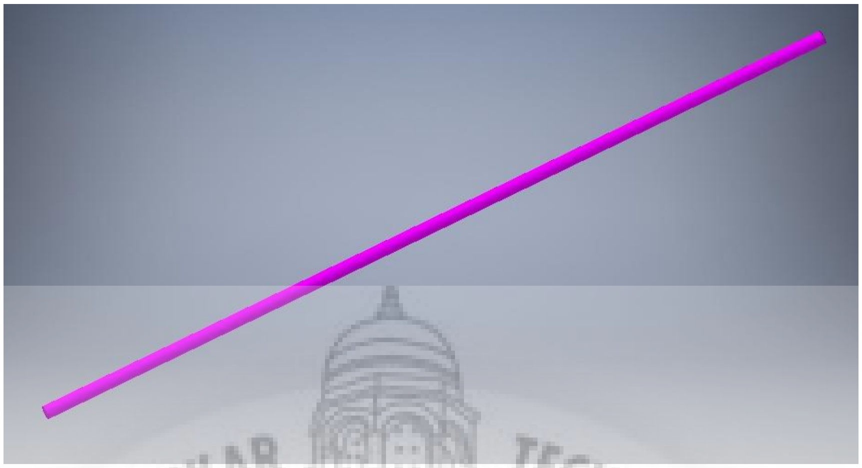
Connecting Rod 1 and Rod 2 are connected between Bed and Base shaft it will provide support to Bed for easy and smooth movement. Shaft1 and shaft2 slide over base shaft so that Bed can move up and down.

3.4.6) Main Linkages Cr:

It will slide on base shaft so that bed can move up and down

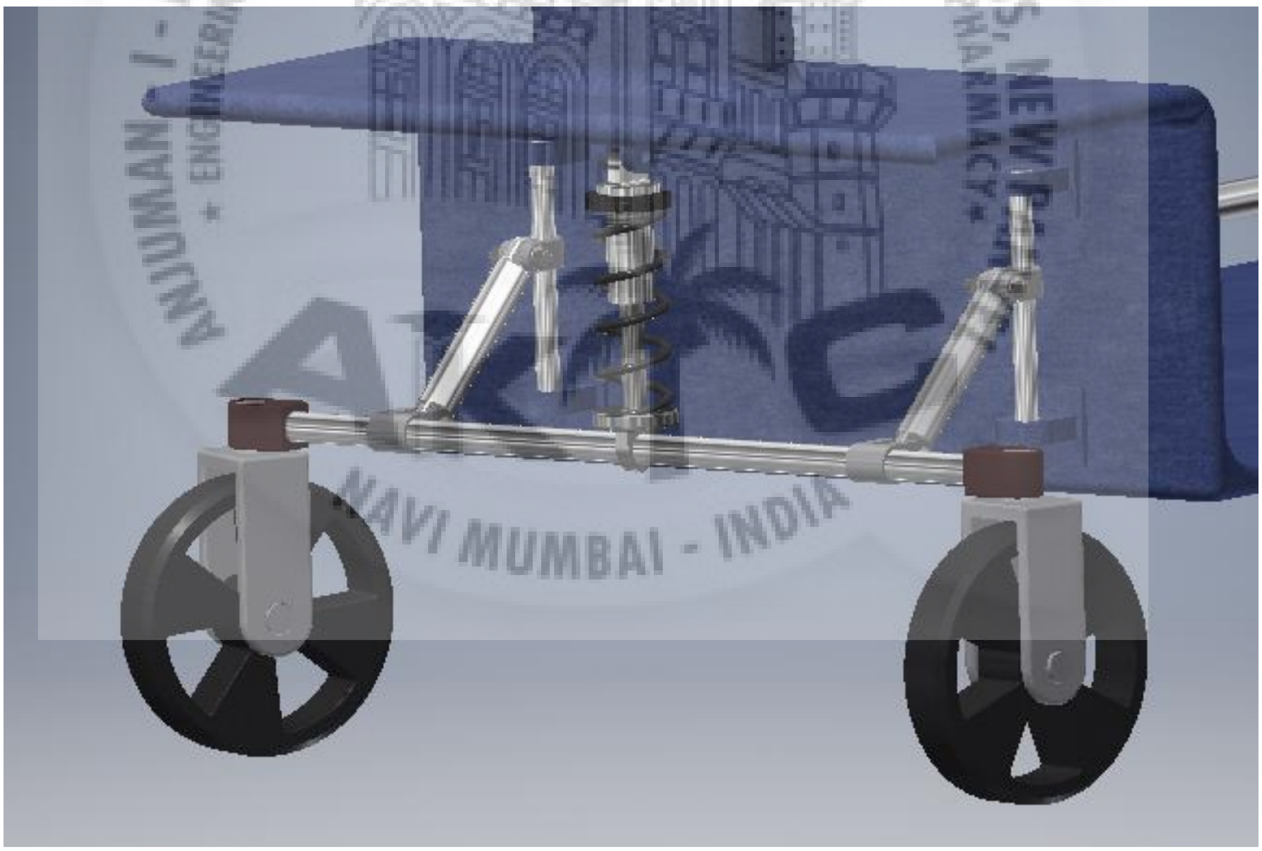
3.4.7) Suspension Linkages:

3.4.8) Base shaft:



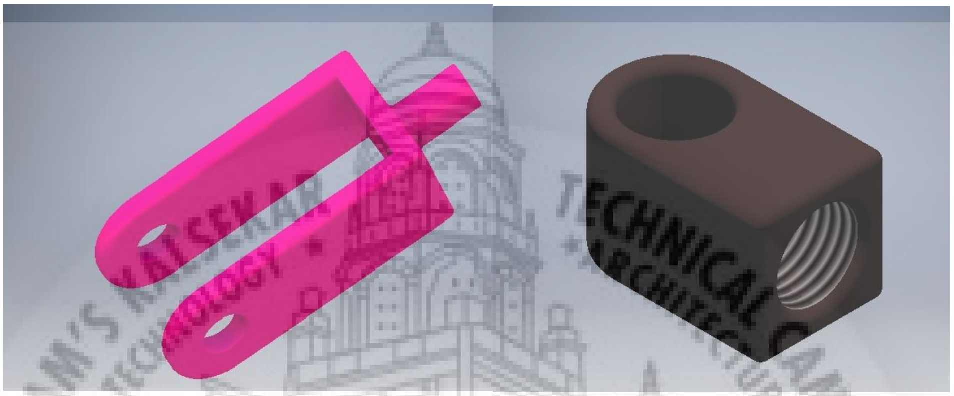
It gives support to the bed, it is connected to a bearing so that it can easily rotate.

3.4.9) Suspension system:



The suspension system is mounted between below Base and above tyer system. Shock absorber has piston and cylinder filled with fluid and spring. Whenever jerk comes piston cylinder move up slowly as compares to spring and release spring energy to come out equilibrium position. It absorbs shock and vibration and provide smooth ride and patient feel batter.

3.4.10) Tyres systems



It is use to move stretcher Bed one place to other place tyer can rotate any direction smoothly

3.4.11) Tyres:

It is used to move stretcher bed

3.5) Cost Estimation

3.5.1) Prototype Cost

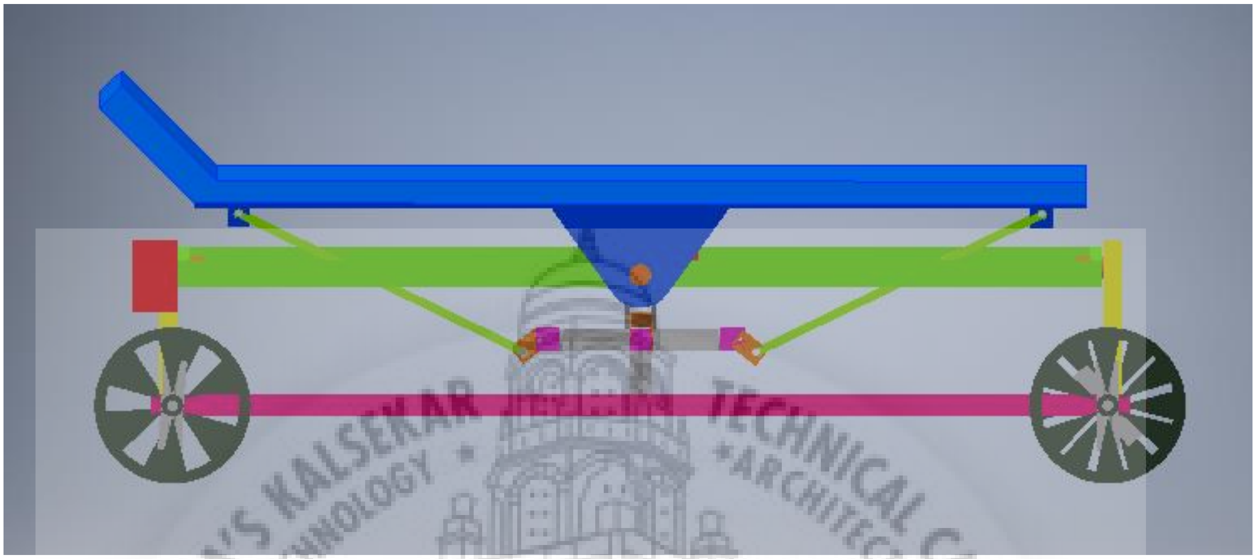
Sr.no	Particular	Cost
1	Number of Specimen	
1.1	Arduino	600
1.2	Servo Motor MG995	1500
1.3	Battery	1000
1.4	Jumper Wire	200
	Breadboard	200
	Tyre	450
1.5	MPU 6050 Sensor	500
2	Set Up	
2.1	Full structure	4000
3	M/C Work	
3.1	Lathe	1000
3.2	Grinding & Drilling Machine	
4	Miscellaneous	
4.1	Others	500
	Total	9050

3.5.2) Real life Cost

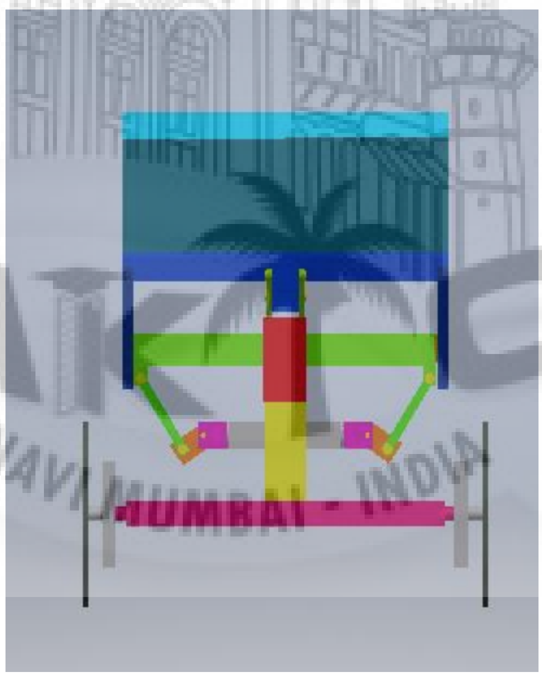
Sr.no	Particular	Cost
1	Number of Specimen	
1.1	Arduino	2500
1.2	Servo Motor	5000
1.3	Battery	2000
1.4	Jumper Wire	200
	Breadboard	200
	Tyre	1000
1.5	MPU 6050 Sensor	500
2	Set Up	
2.1	Full structure	10000
3	M/C Work	
3.1	Lathe, Milling Machine	5000
3.2	Grinding & Drilling Machine	
4	Miscellaneous	
4.1	Others	1000
	Total	25000

3.5) DESIGN:

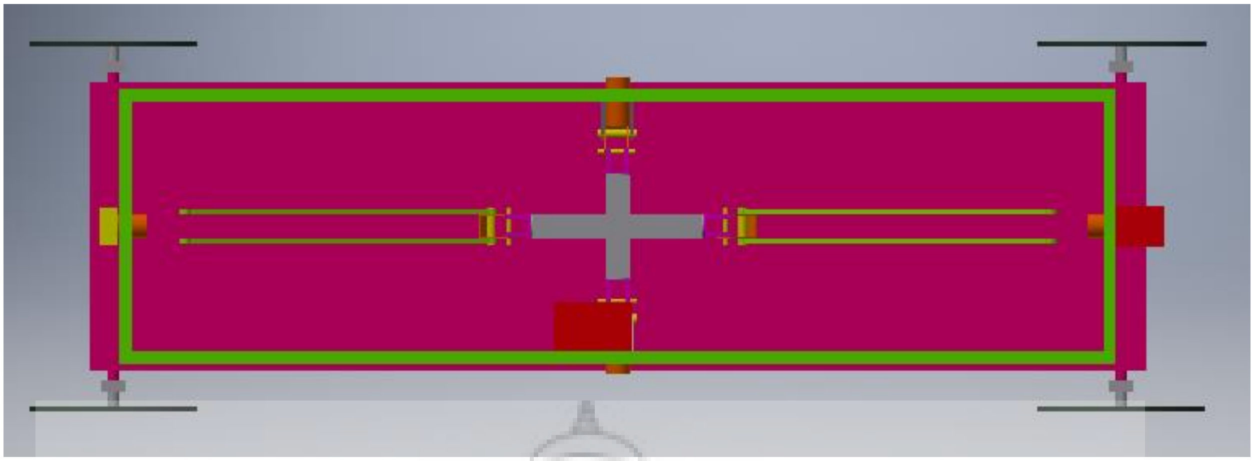
3.5.1) DESIGN 1



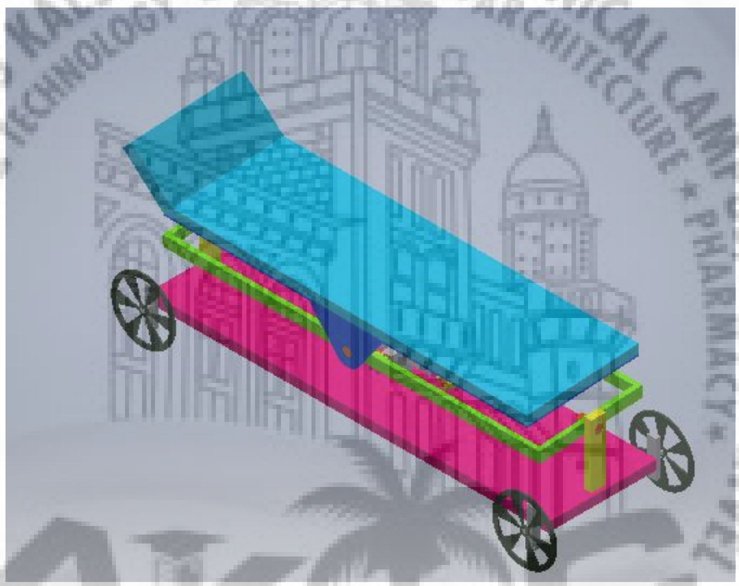
FRONT VIEW



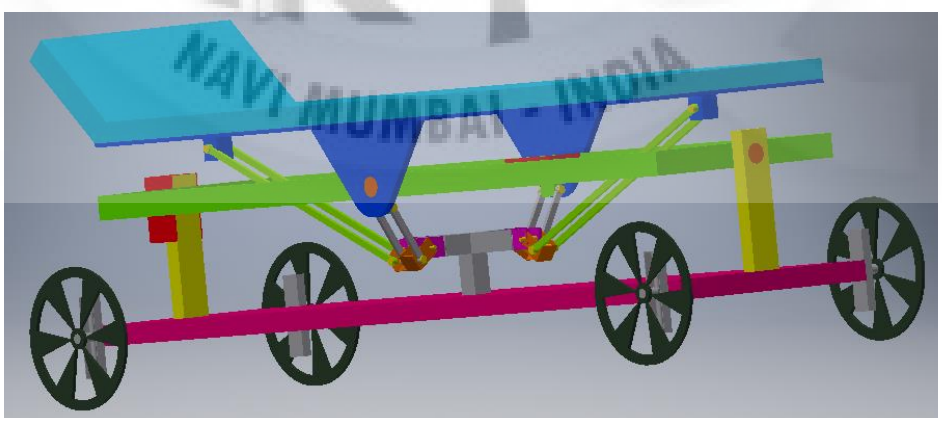
SIDE VIEW



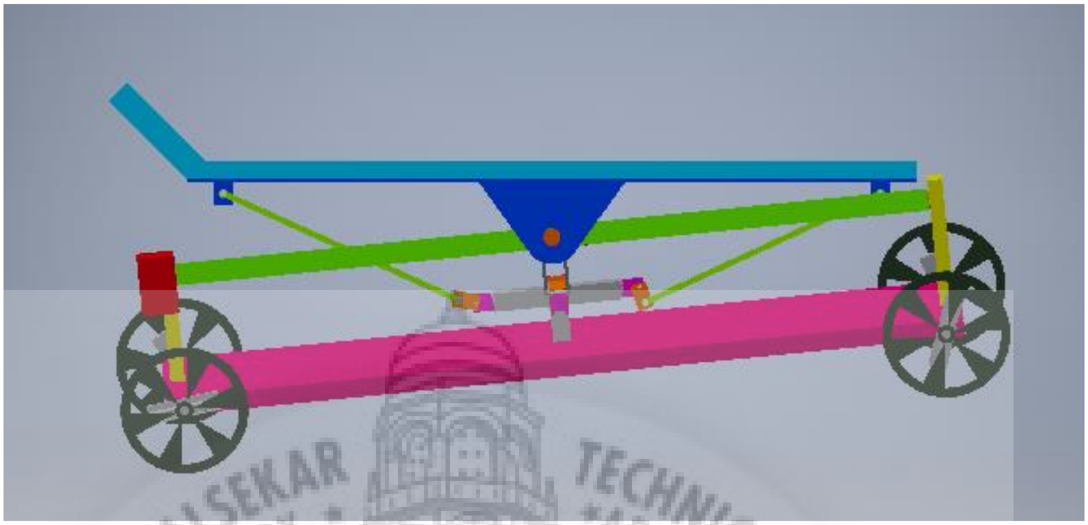
TOP VIEW

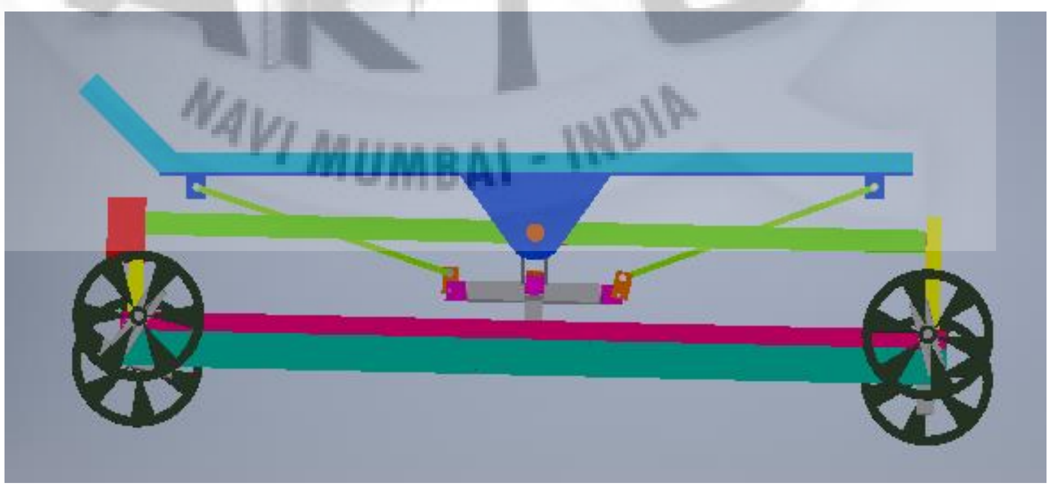


ISO VIEW

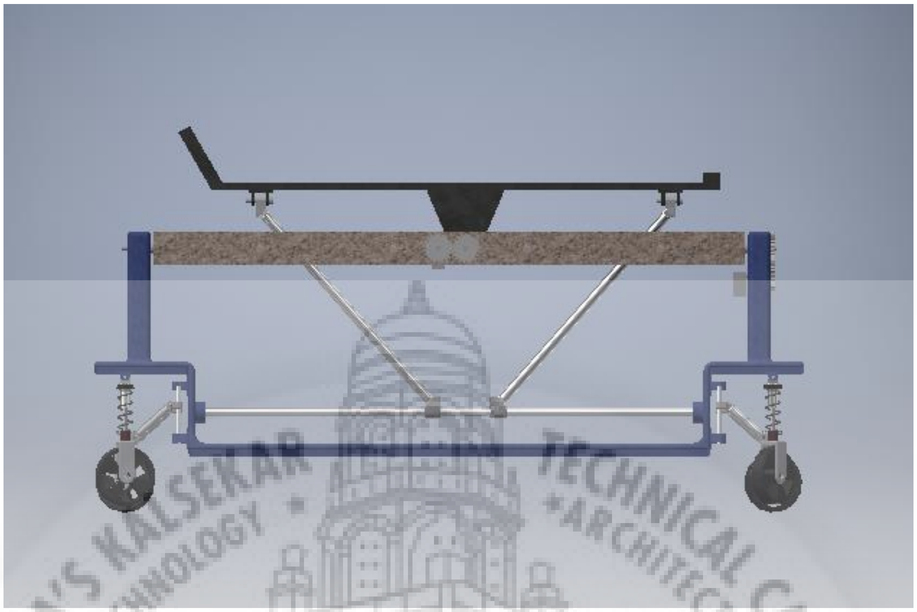


3.5.1.1) With some angle and rotation

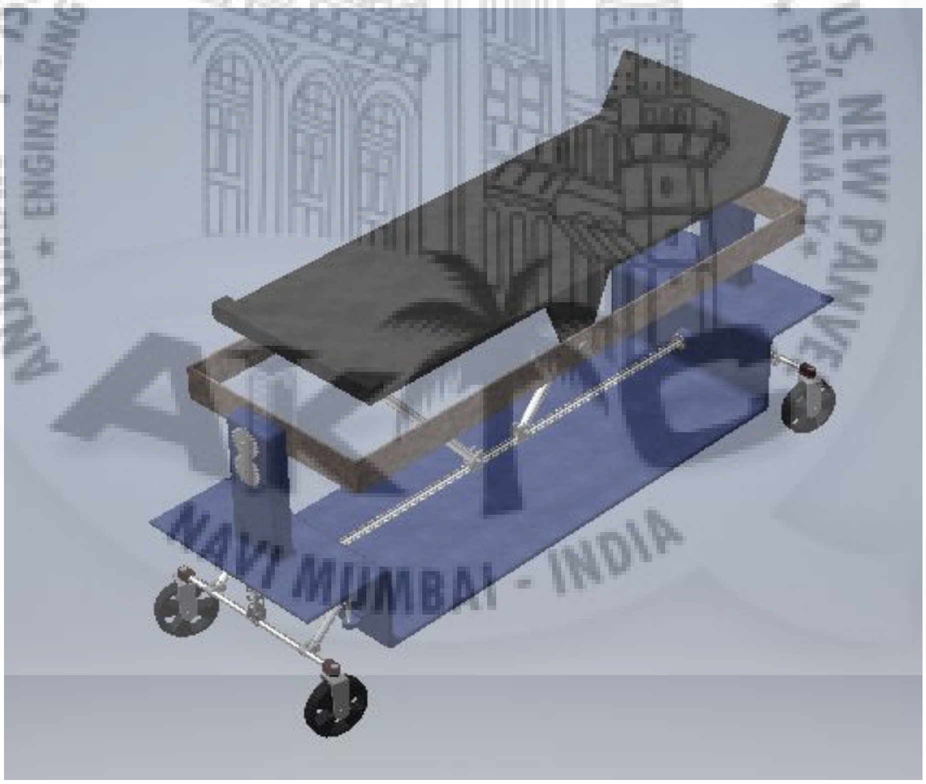




3.5.2) Design 2

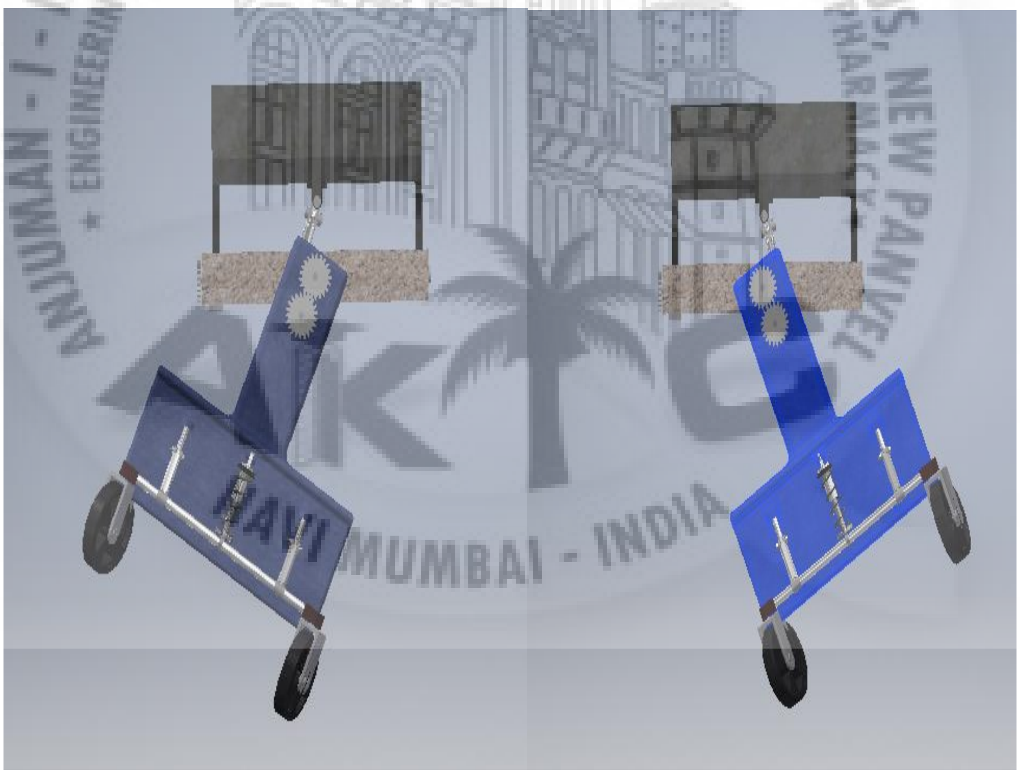


FRONT VIEW



ISOMETRIC VIEW

SIDE VIEW

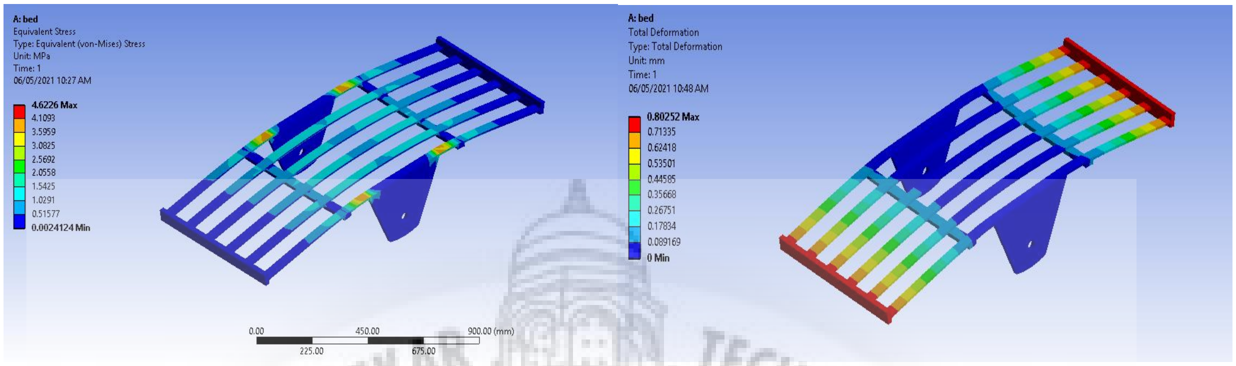


SOME ANGLE

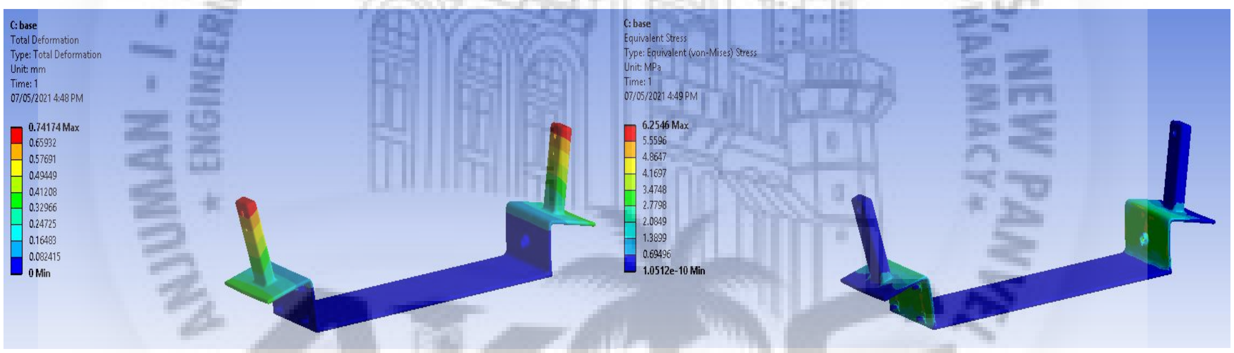
SOME ANGLE

3.6) Analysis

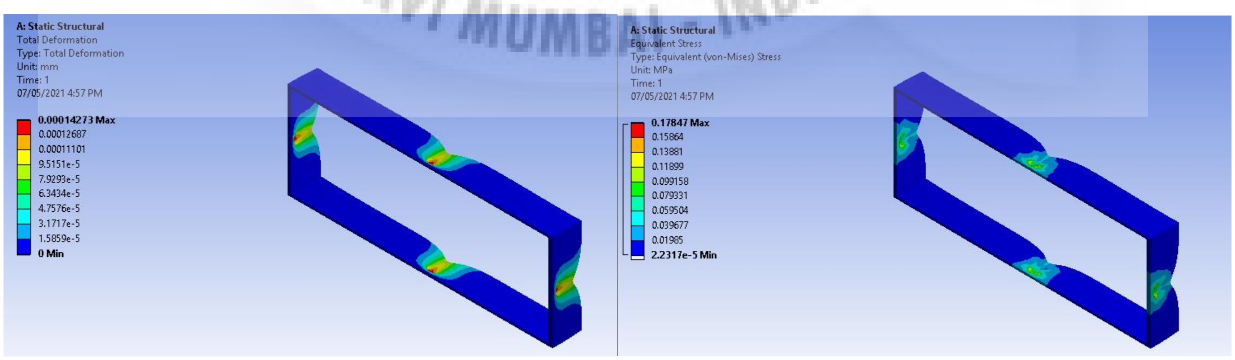
3.6.1) Bed



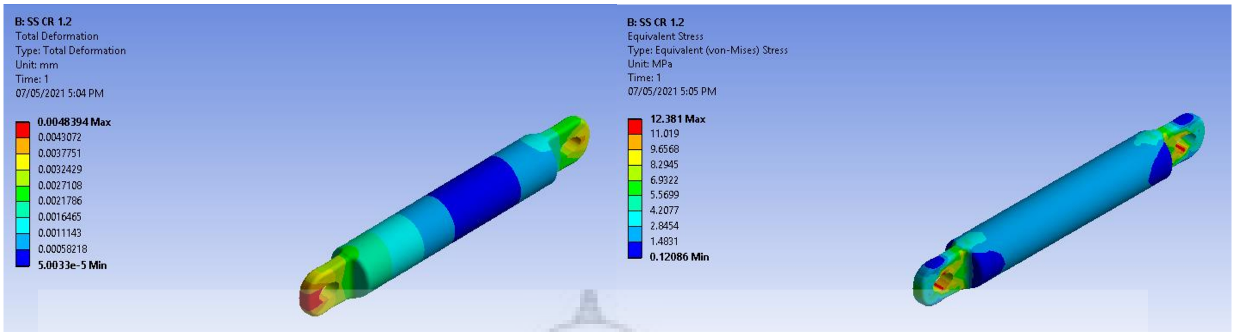
3.6.2) Base



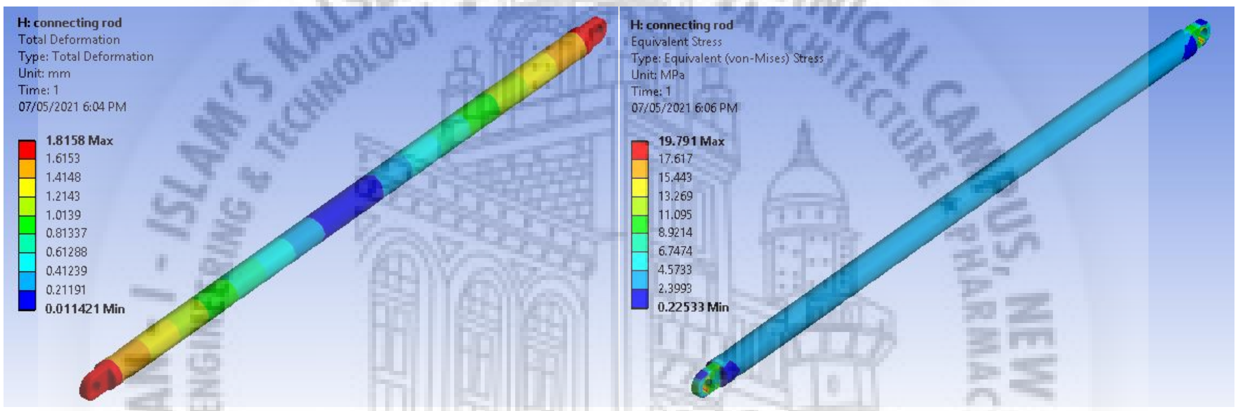
3.6.3) Rolling Control



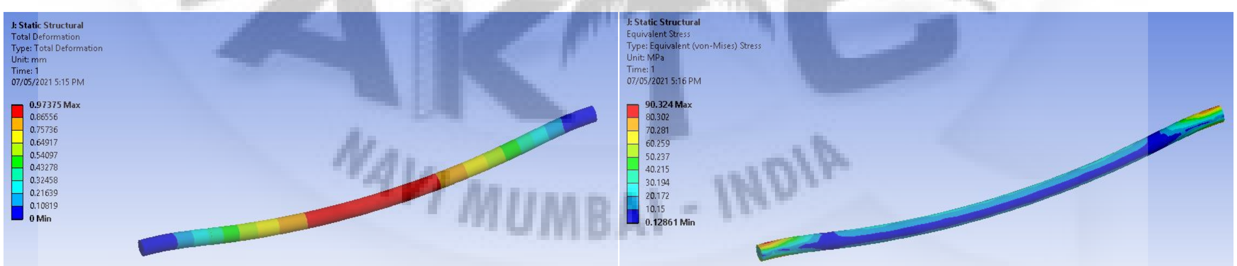
3.6.4) Connecting Rod 1



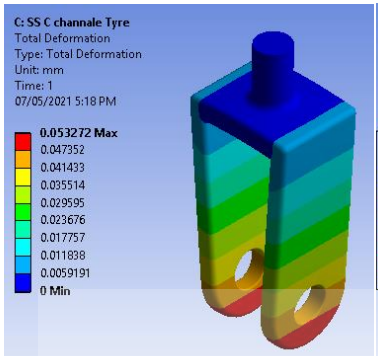
3.6.5) Connecting Rod 2

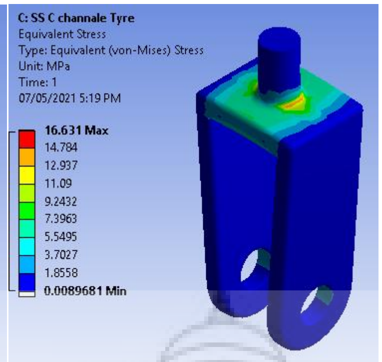


3.6.6) Axle Shaft

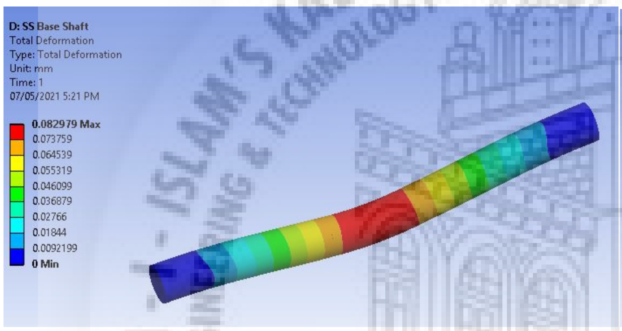


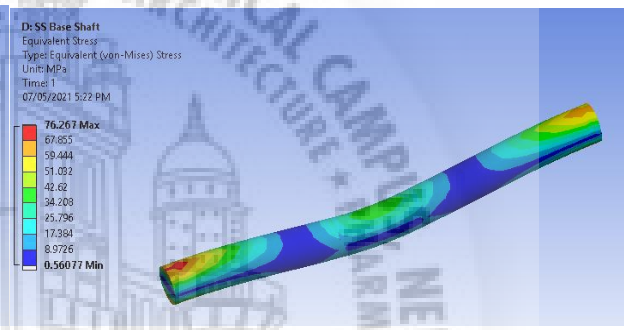
3.6.7) Tyre C Support



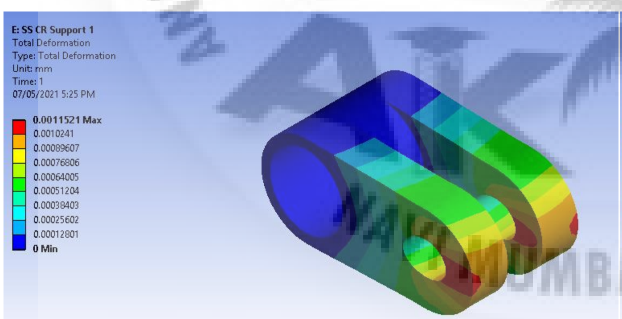


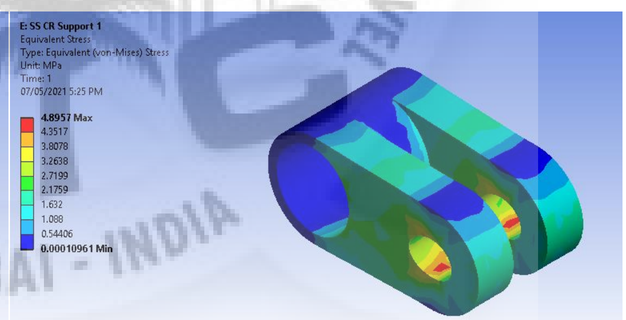
3.6.8) Suspension support Shaft





3.6.9) Support





3.8) ARDUINO PROGRAM

```
#include "I2Cdev.h"
#include "MPU6050_6Axis_MotionApps20.h"
#include "MPU6050.h"
#if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
#include "Wire.h"
#endif
#include <Servo.h>

MPU6050 mpu;
Servo servo1;
Servo servo2;
float correct;
int j = 0;

#define OUTPUT_READABLE_YAWPITCHROLL
#define INTERRUPT_PIN 2
bool blinkState = false;
bool dmpReady = false;
uint8_t mpuIntStatus;
uint8_t devStatus;
uint16_t packetSize;
uint16_t fifoCount;
uint8_t fifoBuffer[64];
Quaternion q;
VectorInt16 aa;
VectorInt16 aaReal;
VectorInt16 aaWorld;
VectorFloat gravity;
float euler[3];
float ypr[3];
uint8_t teapotPacket[14] = { '$', 0x02, 0, 0, 0, 0, 0, 0, 0, 0, 0x00, 0x00, '\r', '\n' };
volatile bool mpuInterrupt = false;
void dmpDataReady()

{
 mpuInterrupt = true;
}

void setup()
 {
#if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
Wire.begin();
```

```
Wire.setClock(400000);
#elif I2CDEV_IMPLEMENTATION == I2CDEV_BUILTIN_FASTWIRE
Fastwire::setup(400, true);
#endif
Serial.begin(38400);
while (!Serial);
Serial.println(F("Initializing I2C devices..."));
mpu.initialize();
pinMode(INTERRUPT_PIN, INPUT);
devStatus = mpu.dmpInitialize();
mpu.setXGyroOffset(17);
mpu.setYGyroOffset(-69);
mpu.setZGyroOffset(27);
mpu.setZAccelOffset(1551);

  if (devStatus == 0)
 {
Serial.println(F("Enabling DMP..."));
mpu.setDMPEnabled(true);
attachInterrupt(digitalPinToInterrupt(INTERRUPT_PIN), dmpDataReady, RISING);
mpuIntStatus = mpu.getIntStatus();
Serial.println(F("DMP ready! Waiting for first interrupt..."));
dmpReady = true;
packetSize = mpu.dmpGetFIFOPacketSize();
}
else
{

   // ERROR!

   // 1 = initial memory load failed

   // 2 = DMP configuration updates failed

   // (if it's going to break, usually the code will be 1)

   // Serial.print(F("DMP Initialization failed (code "));

   //Serial.print(devStatus);

   //Serial.println(F(")"));

  }

// Define the pins to which the 3 servo motors are connected
```

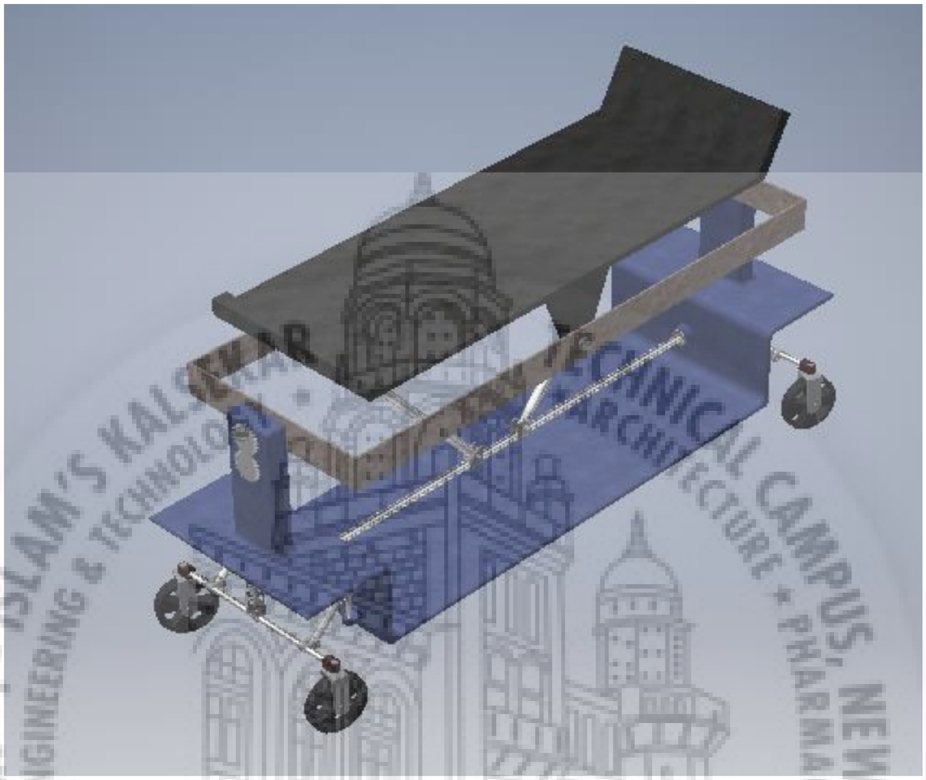
```
  servo1.attach(9);
  servo2.attach(8);
}
void loop() {

 if (!dmpReady) return;

 while (!mpuInterrupt && fifoCount < packetSize) {

 if (mpuInterrupt && fifoCount < packetSize) {

     fifoCount = mpu.getFIFOCount();

    }

  }
mpuInterrupt = false;
mpuIntStatus = mpu.getIntStatus();
fifoCount = mpu.getFIFOCount();
 if ((mpuIntStatus & _BV(MPU6050_INTERRUPT_FIFO_OFLOW_BIT)) || fifoCount >= 1024)
{

   mpu.resetFIFO();
fifoCount = mpu.getFIFOCount();
Serial.println(F("FIFO overflow!"));
} else if (mpuIntStatus & _BV(MPU6050_INTERRUPT_DMP_INT_BIT)) {

   while (fifoCount < packetSize) fifoCount = mpu.getFIFOCount();
mpu.getFIFOBytes(fifoBuffer, packetSize);
fifoCount -= packetSize;

#ifdef OUTPUT_READABLE_YAWPITCHROLL

    mpu.dmpGetQuaternion(&q, fifoBuffer);

    mpu.dmpGetGravity(&gravity, &q);

    mpu.dmpGetYawPitchRoll(ypr, &q, &gravity);

   ypr[0] = ypr[0] * 180 / M_PI;

    ypr[1] = ypr[1] * 180 / M_PI;

    ypr[2] = ypr[2] * 180 / M_PI;

      if (j <= 300) {

      correct = ypr[0];

      j++;
```

```
    }
    else {
      ypr[0] = ypr[0] - correct;
      int servo0Value = map(ypr[0], -90, 90, 0, 180);
      int servo1Value = map(ypr[1], -90, 90, 0, 180);
      int servo2Value = map(ypr[2], -90, 90, 180, 0);
       servo1.write(servo1Value);
      servo2.write(servo2Value);
    }
#endif
  }
}
```

CHAPTER 4

4.1) RESULT

In this project, we got the output as stabilized platform as shown in fig.



Means for any movement of the movable platform the main platform remains parallel to the earth surface as shown in fig. Therefore when platform till towards -30 degree the servo motor will tilt towards +30 degree to keep the platform horizontal and vice versa.

4.2) OUTCOME

- Control all 3 motion (like Pitching, Yawing, Rolling)
- Control Vibration
- Smooth Running
- Turning movement of all Wheel

4.3) DISCUSSION

4.3.1) Possible error sources

Simplifications have been made regarding the movement of the platform. The demonstrator moves in space, but the movement from each motor is seen as movement in one plane. Therefore the model does not consider motion of the center of mass, other than in its own plane. The theoretical model does not consider static friction. This is perceived as one of the main error sources. Since the motors often compensate for small angular fluctuation, the 20 friction in the motor will most likely affect the required torque considerably. The static friction is not linear, which is why it cannot be considered in the transfer function.

4.3.2) Sensor and step response

Since the overshoot is much smaller than the allowed value there is a chance that the speed of the system could be improved and still have a step response within the requirements.

If the sample time in the discrete time domain is reduced, the system would most likely be easier to control. More tests have to be done to determine if the chosen sample time gives the most efficient control.

CHAPTER 5

5.1) CONCLUSION

Our final project is capable of stabilizing a platform at the proximity of parallel to earth. That means this platform will remain parallel to the earth surface. Improvements can be made by using alternative method to detect the platform position, stronger servos, or adding high sensor to filter the signal. This can be used in many applications like Ships, Vehicles, Ambulance, Camera for entertainment and safety purpose.

5.2) SCOPE OF PROJECT

- **Precise medical surgeries** this is very useful in ships for medical operations precisely by keeping to patients stable. Same can be used in ambulances.
- **Aircrafts stabilizer** an aircraft stabilizer is an aerodynamic surface, it includes one or more movable control surfaces, that provides longitudinal (pitch) and directional (yaw) stability and control. A stabilizer can feature a fixed or adjustable structure on which any movable control surfaces are hinged, or it can itself be a fully movable surface such as a stabilizer.
- **Antenna stabilizer** this is use where the antennas are placed at high heights, which get affect because of wind. Due to this communication can be break, so antenna stabilizer helps to keep antenna at a unique position and communication will take place without any problem.
- **Camera stabilizing** Self-stabilization can be used to stable the cameras in films and in photography.
- **Stabilizing platform in vehicles to prevent motion sickness** In this the sheets can be place on a single platform and this platform can be stabilized using this concept, due to which motion sickness problem can be solve.

Reference

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