

WEIGHT DISTRIBUTION OF HUMAN FOOT FOR ERGONOMIC DESIGN OF SHOE

**A Report of PEE300 Major Project Submitted towards the partial fulfilment of the requirement for the
award
of the degree of
Master of Technology in Engineering Systems**

SUBMITTED BY

**MEHER KUMAR
M.TECH.(VII-SEM) PART TIME
ROLL NO. 1906417**

**DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF ENGINEERING
DAYALBAGH EDUCATIONAL INSTITUTE
(DEEMED TO BE UNIVERSITY)
DAYALBAGH , AGRA-282005
MAY-2022**

CERTIFICATE

This is to certify that **Mr. Meher Kumar** has carried out the project work presented in this report entitled **“WEIGHT DISTRIBUTION OF HUMAN FOOT FOR ERGONOMIC DESIGN OF SHOE”** for the award of **Master of Technology** in Engineering Systems From Faculty of Engineering, Dayalbagh Educational Institute, Agra, under my supervision. The thesis embodies results of original work and studies carried out by student himself and the contents of the thesis do not form the award of any other degree to the candidate or to anybody else.

SUPERVISOR

Dr. D.K.CHATURVEDI

Prof. and Head

Department of Footwear Technology
Faculty of Engineering
Dayalbagh Educational Institute
Dayalbagh, Agra-282005

M TECH COORDINATOR

Prof. MANMOHAN AGARWAL

Electrical Engineering Department
Faculty of Engineering
Dayalbagh Educational Institute
(Deemed to be University)Dayalbagh, Agra-282005
Dayalbagh, Agra-282005

HEAD OF DEPARTMENT

Prof. AJAY KUMAR SAXENA

Faculty of Engineering
Dayalbagh Educational Institute
(Deemed to be University)

DECLARATION

I hereby declare that the project work entitled **“WEIGHT DISTRIBUTION OF HUMAN FOOT FOR ERGONOMIC DESIGN OF SHOE”** submitted to the Dayalbagh Educational Institute (Deemed to be University), Agra , is a record of the original work done by me under the guidance of **Professor D. K. Chaturvedi**, and the project work is submitted in the partial fulfilment of the requirements for the award of the degree of Master of Technology in Engineering Systems . The results embodied in the report have not been submitted to any other University or Institute for the award of any degree.

Date:-

Meher Kumar

ACKNOWLEDGEMENTS

I would like to express my gratitude to my project guide Dr. D.K. Chaturvedi, Department of Footwear Technology, Dayalbagh Educational Institute (D.E.I), Prof. and Head, Agra for his pain staking whole hearted efforts and the valuable guidance at each stage of the development of project.

I would also like to thanks Prof. V.SOAMI DAS, Dean, Faculty of Engineering, D.E.I for providing the facilities during the work .

I would alsolike to thanks Prof. A.K.Saxena, Head of the Electrical Department and Prof. Manmohan, Coordinator M.Tech., Faculty of Engineering, for his valuable suggestions during the progress of the project work.

Finally, I am thankful to my near and dear ones related to this project.

Date :-

Place:-

Meher Kumar

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List of Abbreviations

Uneven weight distribution:-

Uneven weight distribution leads to spinal imbalances, abnormally stress bones, joints, muscles, ligaments, tendons, and discs, leading to unnatural wear and tear, fatigue, and finally pain. In turn this can irritate nerves, alter body function, and cause disease. The movements become stiff, you look older and suffer from premature aging.

Extrinsic Muscles and Tendons:-

The extrinsic muscles and tendons start in the lower leg and wrap around the ankle in various ways before attaching to some part of the foot. They form a kind of sock, constructed out of crisscrossing straps of muscle and tendon tissue, which joins the leg to the foot and enables the foot to move in several directions.

ErgonomicallyDesign:-

An ergonomically designed shoe, which includes anatomical arch support, will keep the feet in the proper position and shape to be fully functional and pain-free. Absorbs shock. Ergonomic soles help reduce pressure on the heel and avoid shocks on the entire body, helping alleviate long-term foot, back and knee pain.

Anatomical arch support:-

An arch support is a term used for a large variety of shoe inserts that help support the arches of the foot.

Abstract

Human weight is distributed unevenly in unhealthy person .So to improve it , a proper balancing of weight distribution on human foot is required . Therefore, an Ergonomically designed shoe is mandatory. This work moves forward towards identifying the uneven distribution of weight on feet and would proceed towards identifying the disease using deep learning in MATLAB & also proceed to changes in shoe design concerning with acupressure points specific for a person .

Ergonomics involves designing the workplace to fit the needs of the user rather than trying to make the user adjust to the product. Ergonomics uses anthropometrical data to determine the optimum size, shape and form of a product, and make it easier for people to use. Ergonomists can help to identify which user characteristics should be taken into account during design process. An ergonomically designed shoe, which includes anatomical arch support, will keep feet in the proper position and shape to be fully functional and pain-free. Ergonomic soles help in reducing pressure on the heel and avoid shocks on the entire body, helping alleviate long-term foot, back and knee pain. An ergonomic sole provides extra protection by cushioning, contouring and supporting the foot. This increases blood circulation and reduces muscle strain. By reducing fatigue in feet ,thereby , reducing overall body fatigue. Efforts to meet this concern are further multiplied by the critical factors to be considered in the design of each shoe: shock absorption, flexibility, fit, traction, sole wear, breathability, weight, etc.

A firm arch that is too high will be painful. A soft arch that foot compresses will not provide long term relief. As the arch of the foot is squeezed against the upper, the upper pushes back against the arch. That force against the arch could cause pain. In this case, again, the more likely cause of the pain is the width, not arch supports. Incorrectly sized arch supports can cause restrictions in one's foot movement and force to accommodate the awkward position, putting extra pressure on the midsole and causing more pain. Worn-out insoles will no longer provide the correct support to the feet and could cause more harm than good. High-heel is the target because of the marketing value and the challenge for ergonomics. The center of gravity of the subject should be aligned with the heel region of the foot. Most of the body weight is concentrated at the heel region, then metatarsal region and the toes. When we walk, most of our weight passes from the heel, along the outside of the foot, then across the ball of the foot, and to the big toe. The big toe is a push-off point for the next stride. A number of authors and researchers have estimated the mean percentage plantar weight distribution of body weight in the standing position as 57 percent on the heel and 43 percent on the forefoot and arch. The posture while standing should look like a straight line from the ankle to the hip to the shoulder. One should slightly bend the knees to prevent cutting off circulation to the legs and should hold the weight of body mostly on the balls of feet. One foot should also be about shoulder-width apart .

Taking all this features , the weight distribution at acupressure points on foot need to be calculated. In this direction, this dissertation contains the work for measuring the weights on human foot at different points, which will help in ergonomic design of shoe. I also helps in proper material selection or composite sole for shoe. This will also help in diagnosing the disease and its treatment in further course.

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CHAPTER 1

INTRODUCTION

The foot has two important functions:

1. It support the body weight
2. Lever to propel the body forward in walking and running

To serve these functions foot has many series of small bones and designed in a form of elastic arches or springs.

The human body weight should be distributed fairly evenly within about 5 lbs plus or minus. It's a great predictor of posture, overuse injuries as well as pain patterns. Uneven weight distribution leads to spinal imbalances, abnormally stress bones, joints, muscles, ligaments, tendons, and discs, leading to unnatural wear and tear, fatigue, and finally pain. In turn this can irritate nerves, alter body function, and cause disease. The individual movements become stiff; the person looks older and suffers from premature aging.

SYMPTOMS ASSOCIATED WITH UNEVEN WEIGHT DISTRIBUTION

Heel Spurs, Bunions, Repetitive Ankle Sprains, Runner's Knee (occurs from abnormal patella tracking), Iliotibial Band Syndrome, Outer knee or hip pain, Shin Splints, Plantar Fasciitis, Hip Pain, Low Back or Neck Pain, Muscular Imbalance and fatigue .

CAUSES OF UNEVEN WEIGHT DISTRIBUTION

Lateral spinal curvatures such as scoliosis, Pelvic torsion i.e. short leg syndrome anatomical or functional, Flat arches- arches are not the same in both feet are the major causes. A weakness of one or more lower extremity muscles, which allows the pelvis to move forward or backward in relationship to the other side and an abnormal range of motion along the lower extremity joints.



FIGURE 1.1:- STABLE AND UNSTABLE POSTURE

The foot is classified into 3 types: Normal arched foot, high arched foot and flat foot. The foot serves as the platform that bears the weight of the body. Some researchers and clinicians consider flatfoot and high-

arched as deformity. When the body weight is transferred, the pressure is distributed most strongly in the hindfoot, then decreasingly in the midfoot and forefoot. The distribution corresponds to 60% (rearfoot) to 40% (midfoot and forefoot).

Standing with front foot facing forwards and the back foot turned 45 degrees to the side, one should keep the feet quite close together. Weight distribution: 90 percent of the weight is on the rear leg. Additionally, the front foot should be up on the ball of the foot (heel off the ground).

Ideally, one should stand with feet parallel as much as possible, and line our kneecaps up to point over the center of ankles. Standing with parallel feet and legs is a simple idea that can take a fair amount of practice.

The extrinsic muscles and tendons start in the lower leg and wrap around the ankle in various ways before attaching to some part of the foot. They form a kind of sock, constructed out of crisscrossing straps of muscle and tendon tissue, which joins the leg to the foot and enables the foot to move in several directions.

An ergonomically designed shoe, which includes anatomical arch support, will keep the feet in the proper position and shape to be fully functional and pain-free and absorbs shock. Ergonomic soles help reduce pressure on the heel and avoid shocks on the entire body, helping alleviate long-term foot, back and knee pain.

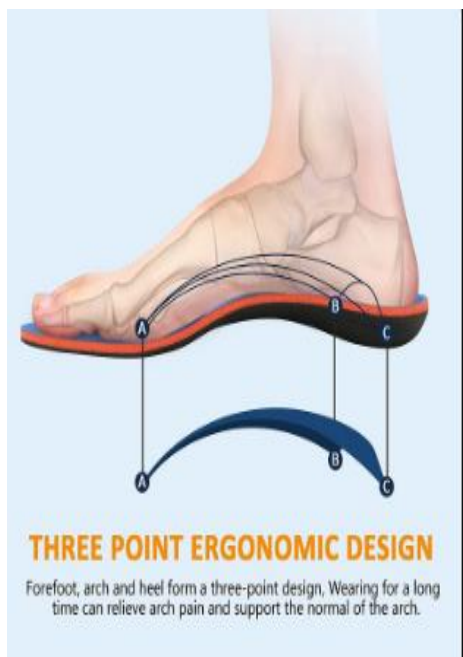




FIGURE 1.2 VARIOUS SUPPORTING POINTS ON FOOT

The three point ergonomic design takes care of forefoot, arch and heel while the four point ergonomic design provides better foot lateral arch support in addition to three point. The lateral longitudinal arch is mostly involved in transmitting this weight and makes more contact with the ground than the medial one. The arch support play an important role when walking and running as they help in propel forward.

PROBLEM STATEMENT-

Measurement of body weight on human foot at discrete points while standstill using weight sensors and display systems.

OBJECTIVE-

1. Identify different points on foot for weight measurement for Ergonomic design of shoe.
2. Select suitable weight sensors for measurements.
3. Design and develop the circuit for display of weights for different points of foot.
4. Experimentation and validation of results.
5. Analysis of results.

CHAPTER 2

LITERATURE REVIEW

The weight distribution pattern of foot of any person under static position normally depends on the body posture. During stand, minisquat, squat and one leg stand positions have different weights [4]. Similarly, the weight distribution of foot of human are different during different activities like running jogging, jumping, standing on two legs, standing on one lag etc. In walking transmission of weight borne by the foot is successively transferred along the heel, lateral border and the ball of foot and anterior pillar of the medial longitudinal arch (refer fig. 1).

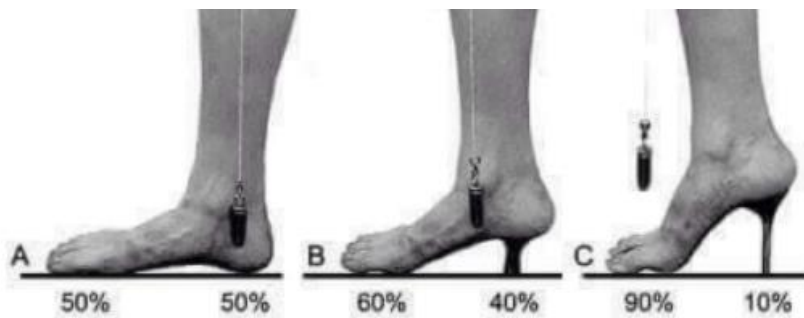


FIG. 2.1 WEIGHT DISTRIBUTION DURING WALKING

[taken from <https://www.pinterest.co.uk/pin/475692779387971615/>]

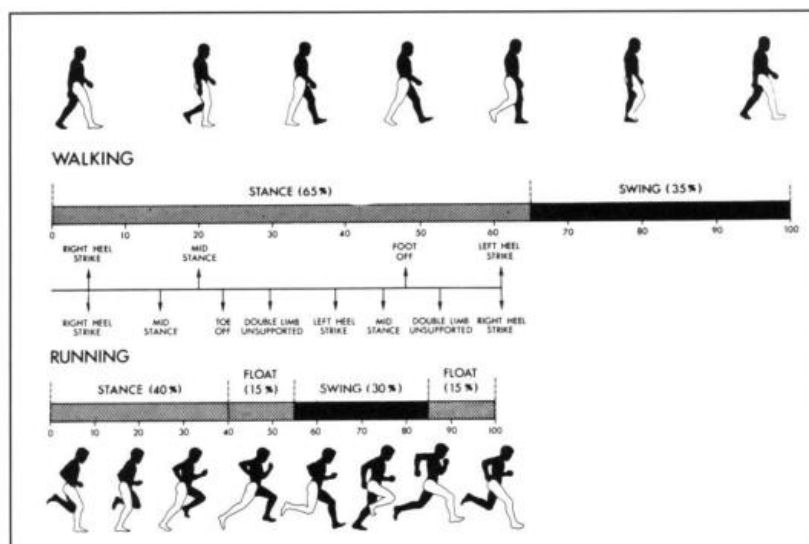


FIG. 2.2 COMPARISON OF WALKING AND RUNNING CYCLE [10]

In running the heel remains above the ground and take off point is maintained by the anterior pillar of the medial longitudinal arch. Body weight distribution of the left (50.07%) and right (50.12%) foot was balanced [11]. The pressure in the rearfoot was higher than in the forefoot. A number of authors and researchers have estimated the mean percentage plantar weight distribution of body weight in the standing position as 57 percent on the heel and 43 percent on the forefoot and arch [5]. Many studies conducted in the past for weight distribution of foot and disease identification, but nobody is using it for ergonomic design of shoe. In a recent study, it has been estimated as 60 percent of body weight on the rear foot, 8 percent on the mid foot, 28 percent on the forefoot and 4 percent on the toes, but most of these studies have been done for the standing position alone [6,7]. The percentage weight (load) distribution in standing position over the great and 2nd toes, the lateral three toes, anterior half of the medial arch, anterior half of the lateral border, posterior half of the medial arch, posterior half of the lateral border, and the heel region of the left foot were 4.8%, 4.1%, 2.1%, 7.4%, 1.6%, 5.8%, and 24.0% and for right foot 4.9%, 4.1%, 2.2%, 7.5%, 1.6%, 5.7%, and 24.2% respectively. With change of position from stand to minisquat, the load shifted anteriorly and the percentage weight (load) distribution for the left foot was 8.2%, 5.9%, 3.4%, 8.7%, 1.8%, 4.6%, and 17.1% and for the right foot was 8.2%, 6.0%, 3.5%, 8.8%, 1.8%, 4.8%, and 17.3% respectively. During shift from minisquat to squat, the weight (load) shifted posteriorly with percentage weight (load) distribution for the left foot 4.0%, 3.4%, 1.6%, 7.6%, 2.5%, 5.1%, and 25.0% and for the right foot 4.2%, 3.4%, 1.6%, 8.1%, 2.6%, 5.0% and 25.9% respectively. In the left leg stand position, the percentage weight (load) distribution was 19.1%, 11.1%, 5.8%, 18.6%, 3.6%, 12.6%, and 29.3%, whereas in the right leg stand, it was 19.3%, 11.1%, 6.2%, 18.3%, 3.5%, 12.3%, and 29.2% respectively. There was minimal difference in percentage weight (load) distribution between left leg stand and right leg stand positions.

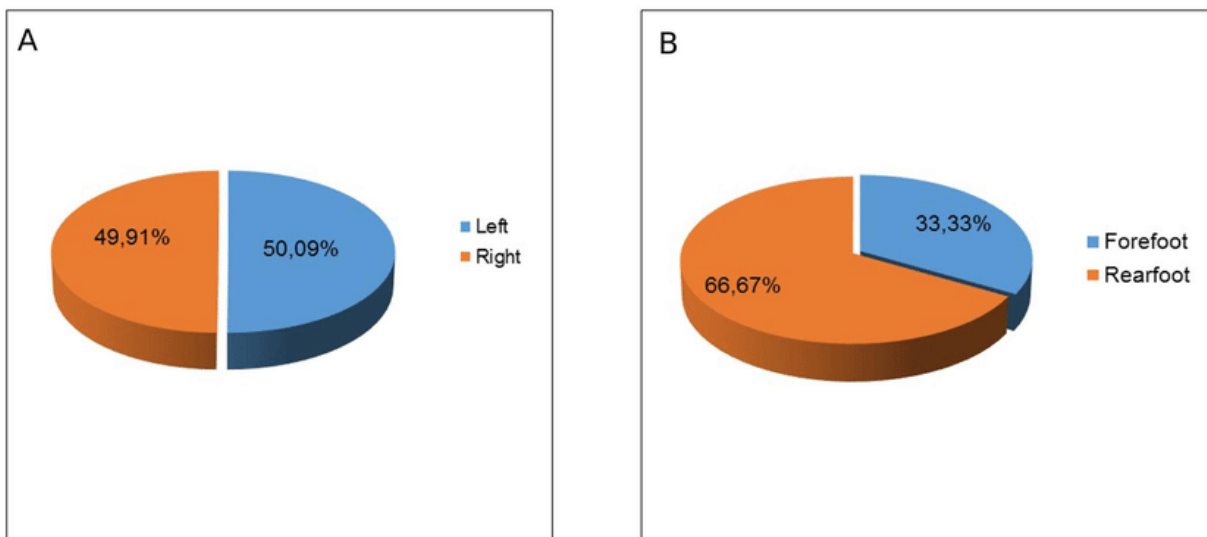


FIG. 2.3 PIE CHART INDICATING WEIGHT DISTRIBUTION

Table 2.1:- MEAN VALUE OF WEIGHT DISTRIBUTION. (Heidelberg, 2015)

	Mean value
Balance left	50.07
Balance right	50.12
Forefoot left	45.49
Forefoot right	44.26
Rearfoot left	54.14
Rearfoot right	55.09
Maximum pressure	12.5
Left	11.05
Right	11.00
Forefoot left	8.23
Forefoot right	8.59
Rearfoot left	9.60
Rearfoot right	9.51

Table 2.2 Percentage Plantar Weight Distribution Pattern **Group 1 (Healthy population) and Group 2 (Knee OA) group in Right Foot**

Test Position	Comp	Right Foot									
		Group 1 ^a				Group 2 ^{a,b}				t	p value
		Mean $\pm$ SD		95% CI		Mean $\pm$ SD		95% CI			
Stand	C1	4.9 $\pm$ 1.5	4.6 to 5.2	4.7 $\pm$ 2.3	4.3 to 5.2	0.6	0.545				
	C2	4.1 $\pm$ 1.4	3.8 to 4.4	3.7 $\pm$ 1.9	3.4 to 4.1	1.6	0.106				
	C3	2.2 $\pm$ 1.1	1.9 to 2.4	3.9 $\pm$ 1.9	3.6 to 4.3	-7.7	<.001				
	C4	7.5 $\pm$ 2.2	7.0 to 7.9	7.8 $\pm$ 3.3	7.1 to 8.4	-0.7	0.484				
	C5	1.6 $\pm$ 1.3	1.3 to 1.9	3.7 $\pm$ 3.6	3.0 to 4.4	-5.3	<.001				
	C6	5.7 $\pm$ 2.6	5.2 to 6.3	7.3 $\pm$ 4.7	6.4 to 8.2	-2.8	0.005				
	C7	24.2 $\pm$ 4.2	23.3 to 25.0	21.5 $\pm$ 7.9	20.0 to 23.0	2.9	0.004				
Mild to Squat	C1	8.2 $\pm$ 2.1	7.8 to 8.6	10.3 $\pm$ 6.0	9.2 to 11.5	-3.2	0.002				
	C2	6.0 $\pm$ 1.9	5.6 to 6.4	6.2 $\pm$ 3.4	5.5 to 6.8	-0.4	0.703				
	C3	3.5 $\pm$ 1.6	3.2 to 3.8	5.8 $\pm$ 3.0	5.2 to 6.4	-6.6	<.001				
	C4	8.8 $\pm$ 2.4	8.3 to 9.3	8.8 $\pm$ 4.0	8.1 to 9.6	0.0	0.994				
	C5	1.8 $\pm$ 1.3	1.5 to 2.0	3.1 $\pm$ 3.0	2.5 to 3.6	-3.8	<.001				
	C6	4.8 $\pm$ 1.9	4.5 to 5.2	5.1 $\pm$ 3.6	4.4 to 5.8	-0.6	0.536				
	C7	17.3 $\pm$ 4.5	16.3 to 18.2	11.3 $\pm$ 6.4	10.0 to 12.5	7.5	<.001				
Squat	C1	4.2 $\pm$ 2.5	3.7 to 4.7	4.2 $\pm$ 3.3	3.5 to 4.8	0.2	0.869				
	C2	3.4 $\pm$ 1.6	3.1 to 3.7	3.5 $\pm$ 2.5	3.0 to 4.0	-0.3	0.727				
	C3	1.5 $\pm$ 1.2	1.3 to 1.8	1.6 $\pm$ 1.5	1.3 to 1.9	-0.2	0.852				
	C4	8.1 $\pm$ 3.3	7.4 to 8.8	8.3 $\pm$ 3.5	7.6 to 8.9	-0.3	0.736				
	C5	2.6 $\pm$ 2.0	2.2 to 3.0	2.6 $\pm$ 2.1	2.2 to 3.0	0.1	0.915				
	C6	5.0 $\pm$ 2.7	4.5 to 5.6	5.1 $\pm$ 3.0	4.5 to 5.6	-0.1	0.942				
	C7	25.9 $\pm$ 6.5	24.5 to 27.2	25.9 $\pm$ 6.9	24.5 to 27.2	0.0	0.994				
One Leg Stand	C1	19.3 $\pm$ 4.3	18.4 to 20.2	9.1 $\pm$ 4.9	8.2 to 10.1	15.5	<.001				
	C2	11.1 $\pm$ 3.2	10.4 to 11.8	7.2 $\pm$ 4.0	6.5 to 8.0	7.6	<.001				
	C3	6.2 $\pm$ 3.3	5.6 to 6.9	7.5 $\pm$ 3.5	6.8 to 8.2	-2.7	0.008				
	C4	18.3 $\pm$ 5.5	17.1 to 19.4	14.5 $\pm$ 5.6	13.5 to 15.6	4.8	<.001				
	C5	3.5 $\pm$ 2.3	3.0 to 3.9	7.2 $\pm$ 6.9	5.9 to 8.5	-5.0	<.001				
	C6	12.3 $\pm$ 4.1	11.5 to 13.2	14.0 $\pm$ 9.0	12.3 to 15.7	-1.6	0.104				
	C7	29.2 $\pm$ 5.6	28.1 to 30.4	40.5 $\pm$ 13.2	38.0 to 43.0	-7.6	<.001				

* Group 1 = Healthy (normal) people group; **Group 2 = Early knee osteoarthritic group
 Compartments (C): C 1 = Greater and 2nd toes; C 2 = Lateral three Toes; C 3 = Proximal (anterior) half of medial arch; C 4 = Proximal (Anterior) half of lateral border; C 5 = Distal (Posterior) half of medial arch; C 6 = Distal (Posterior) half of lateral border; C 7 = Heel region

Taken from ref. [6]

Each leg weighs about 10% of the total weight, and the torso about 60%. But the average person's legs are about half his or her height and the torso about 40% of height. Thus, torsos weigh about 4.5 times as much per inch as legs. When the body weight is transferred, the pressure is distributed most strongly in the hindfoot, then decreasingly in the midfoot and forefoot. The distribution corresponds to 60% (rearfoot) to 40% (midfoot and forefoot). The body adapts to this posture, leaving the pelvis out of balance. This increases the risk for low back pain. The majority of people stand with most of their weight on their heels, which automatically turns the core muscles off.

A typical shoe consists of three basic components: the outsole, the midsole, and the upper. An ergonomic sole provides extra protection by cushioning, contouring and supporting the foot. This increases blood circulation and reduces muscle strain. By reducing fatigue in your feet, you reduce overall body fatigue. The choice of footwear is vital to the health of our feet. Comfortable shoes to prevent injuries, and ergonomic to simulate the natural condition of the foot walking, running, or standing for a long time. One should have the front of the shoe (toe box) with $\frac{1}{2}$ inch space in front of longest toes. An arch shape supports the foot. There should not be more than $1\frac{1}{2}$ inches of heel. There should be a stiff, snug back of the shoe to keep foot from sliding around. The shoes should have a balanced and secure feel throughout range of motion. Also there should be flexibility i.e the shoes should allow for a good degree of give at the base of the toes, providing smooth motion. The sole of a shoe, also known as the outsole, is the bottom part of the shoe that comes in direct contact with the ground. Running shoes will have a stiffer sole; walking shoes have more flex and blend. Heels. Running shoes have thick heel wedges to provide more cushion. A thick heel when walking can actually cause tendinitis or shin splints, and can even cause a walker wearing a running shoe to trip.

The Accupressure points healing shoe involves applying pressure to different points on the bottom of the foot. According to traditional Chinese medicine (TCM), these points correspond to different areas of the body. They are believed to have multiple benefits, including reducing stress, aiding digestion, and promoting sound sleep. Some ancient practices and a growing body of medical research even suggest that massaging specific pressure points on your feet can heal conditions affecting entirely different parts of your body. According to the theory, the acupressure point pressure to feet, hands, or ears sends a calming message from the peripheral nerves in these extremities to the central nervous system, which in turn signals the body to adjust the tension level. There are many benefits of acupressure based ergonomical shoes. It Improves

- 1) blood circulation.
- 2) Lowers blood pressure.
- 3) Encourages better sleep.
- 4) Reduces the effects of anxiety and depression.
- 5) Speeds recovery in foot injuries.
- 6) Reduces edema during pregnancy.
- 7) Boosts energy levels. ...
- 8) Improves immune function.

The entire bottom of your foot corresponds with various organs. Top third (near the ball of your foot): Chest organs, including the lungs and heart. There are 5 of the main body connections to the feet.

- 1) Head and Brain.

2) Small Intestines.

3) The Heart.

4) The Lungs.

5) The Neck.

The various accupressure points are depicted on foot below:-

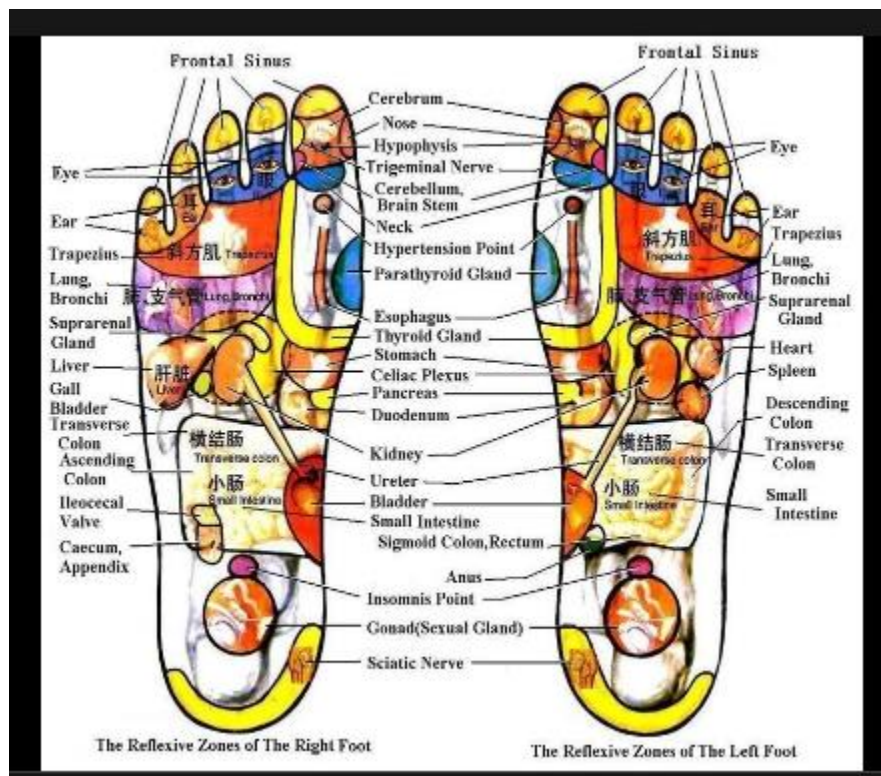


FIGURE 2.4 :- ACCUPRESSURE POINTS ON FOOT

Ergonomics involves designing the workplace to fit the needs of the worker rather than trying to make the worker adjust to the workplace. There are five aspects of ergonomics: safety, comfort, ease of use, productivity/performance, and aesthetics. Ergonomics is a science concerned with the 'fit' between people and their work. Ergonomics is the science of the design of equipment, especially so as to reduce operator fatigue, discomfort and injury. The goal of ergonomics (i.e. the scientific study of people at work) is to prevent soft tissue injuries and musculoskeletal disorders (MSDs) caused by sudden or sustained exposure to force, vibration, repetitive motion, and awkward posture. The objective of ergonomics is to maximize productivity while lowering the risk of Musculoskeletal Disorders (MSDs). There are three primary types of ergonomic hazards: objects, environments, and systems that result in poor posture or unnatural, uncomfortable, or awkward movements. Ergonomic risk factors are workplace situations that cause wear and tear on the body and can cause injury. These include repetition, awkward posture, forceful motion, stationary position, direct pressure, vibration, extreme temperature, noise, and work stress. When evaluating a job, looking for three main characteristics known as Ergonomic Stressors: the force required to complete a task, any awkward or static working postures adopted in completing a task, and the repetitiveness of a task.

CHAPTER 3

EXPERIMENTATION

Arduino Uno is used in this project . The specifications are mentioned below .

Arduino Uno:-

Arduino Uno is the most standard board available and probably the best choice for a beginner. It can be directly connect the board to the computer via a USB Cable which performs the function of supplying the power as well as acting as a serial port.

Vin: This is the input voltage pin of the Arduino board used to provide input supply from an external power source.

5V: This pin of the Arduino board is used as a regulated power supply voltage and it is used to give supply to the board as well as onboard components.

3.3V: This pin of the board is used to provide a supply of 3.3V which is generated from a voltage regulator on the board

GND: This pin of the board is used to ground the Arduino board.

Reset: This pin of the board is used to reset the microcontroller. It is used to Resets the microcontroller.

Analog Pins: The pins A0 to A5 are used as an analog input and it is in the range of 0-5V.

Digital Pins: The pins 0 to 13 are used as a digital input or output for the Arduino board.

Serial Pins: These pins are also known as a UART pin. It is used for communication between the Arduino board and a computer or other devices. The transmitter pin number 1 and receiver pin number 0 is used to transmit and receive the data resp.

External Interrupt Pins: This pin of the Arduino board is used to produce the External interrupt and it is done by pin numbers 2 and 3.

PWM Pins: This pins of the board is used to convert the digital signal into an analog by varying the width of the Pulse. The pin numbers 3,5,6,9,10 and 11 are used as a PWM pin.

SPI Pins: This is the Serial Peripheral Interface pin, it is used to maintain SPI communication with the help of the SPI library. SPI pins include:

SS: Pin number 10 is used as a Slave Select

MOSI: Pin number 11 is used as a Master Out Slave In

MISO: Pin number 12 is used as a Master In Slave Out

SCK: Pin number 13 is used as a Serial Clock

LED Pin: The board has an inbuilt LED using digital pin-13. The LED glows only when the digital pin becomes high.

AREF Pin: This is an analog reference pin of the Arduino board. It is used to provide a reference voltage from an external power supply.

The HX711 Load Cell Amplifier Module is used . The details are below mentioned.

DESCRIPTION:-

HX711 features dual-channel 24 Bit Precision A/D Weight Pressure Sensor Load Cell Amplifier which is available in a small breakout board. The board has pinouts for the microcontroller and the Load cell in two different directions for the ease of interfacing. It can be interfaced with any microcontroller using Data and Clock pins.

This module supports input voltage from 2.7V to 5V, making it ideal for the 3.3V and 5V microcontroller operations. A Resistive Load cell with two differential inputs can be used with this module and could achieve high accuracy in low and high weight measurements.

This low cost, analog front load cell amplifier is the perfect choice for Balance and load cell interfacing. The current consumption of this amplifier is also low with less than 1uA in power down state and 1.5mA only in normal operation or active state.

SPECIFICATIONS AND FEATURES:-

Excitation voltage: 5-10V.

Current consumption: <1uA (Powerdown state), 1.5mA (Normal Operation state)

Differential input channels: 2

On-chip active low noise PGA gain: 32 / 64 / 128 (can be selected)

Has On-chip power supply regulator for load-cell and ADC analogue power supply.

Output Data rate support: 10SPS / 80SPS (can be selected)

Has an oscillator onboard eliminating external components.

Has optional external oscillator

Simple digital control and serial interface: pin-driven controls, no programming needed for ease of usage.

Simultaneous 50 and 60Hz supply rejection for better accuracy.

50KG HALF-BRIDGE EXPERIMENTS BODY SCALE LOAD CELL SENSOR

The 50kg Half-bridge Experiments Body Scale Load Cell Sensor is measuring; the correct force is applied to the outer side of the strain E-shaped beam portion of the sensor (i.e., a strain gauge affixed to the intermediate, adhesive coating with white beam arms); and the outer edges to form a shear force in the opposite direction, i.e., middle strain beam bending necessary changes can occur under stress, strain beam side by another force should not be a barrier.

The sensor can be used with the following three methods:-

Using a sensor with an external resistors full bridge measurement range of a sensor range: 50kg. Higher requirements for an external resistor.

The uses of only two full-bridge sensors measuring range are the range of the two sensors and: $50\text{kg} \times 2 = 100\text{kg}$.

The use of four full-bridge sensors measuring range is the range of four sensors and: $50\text{kg} \times 4 = 200\text{kg}$.

FEATURES OF 50KG HALF-BRIDGE EXPERIMENTS BODY SCALE LOAD CELL SENSOR:-

Internal 1000Ohm half-bridge strain gauge load cell, the range is 50kg, half-bridge structure.

Widely used in hopper scales, platform scales, platform balance, belt scales, and other electronic weighing devices.

This is a half-bridge load sensor, which is widely used in weight scales. When the half-bridge is being stretched, it sends the signal via the red signal wire.

Alloy Steel wired weighing load cell, high accuracy, simple structure, simple installation. You can use multiple load sensors simultaneously to increase the capacity range, Parallel use to add additional capacity.

SPECIFICATIONS OF 50KG HALF-BRIDGE EXPERIMENTS BODY SCALE LOAD CELL SENSOR:-

Capacity (Kg)	50
Output Sensitivity (mv/v)	1 0.1
Nonlinearity (%FS)	0.03
Repeatability (%FS)	0.03
Input Resistance (Ω)	1000
Insulation Resistance (M)	5000
Cable Length (cm)	35
Length (mm)	34
Width (mm)	34

Height (mm)

8

Weight (gm)

20

CIRCUIT DIAGRAM

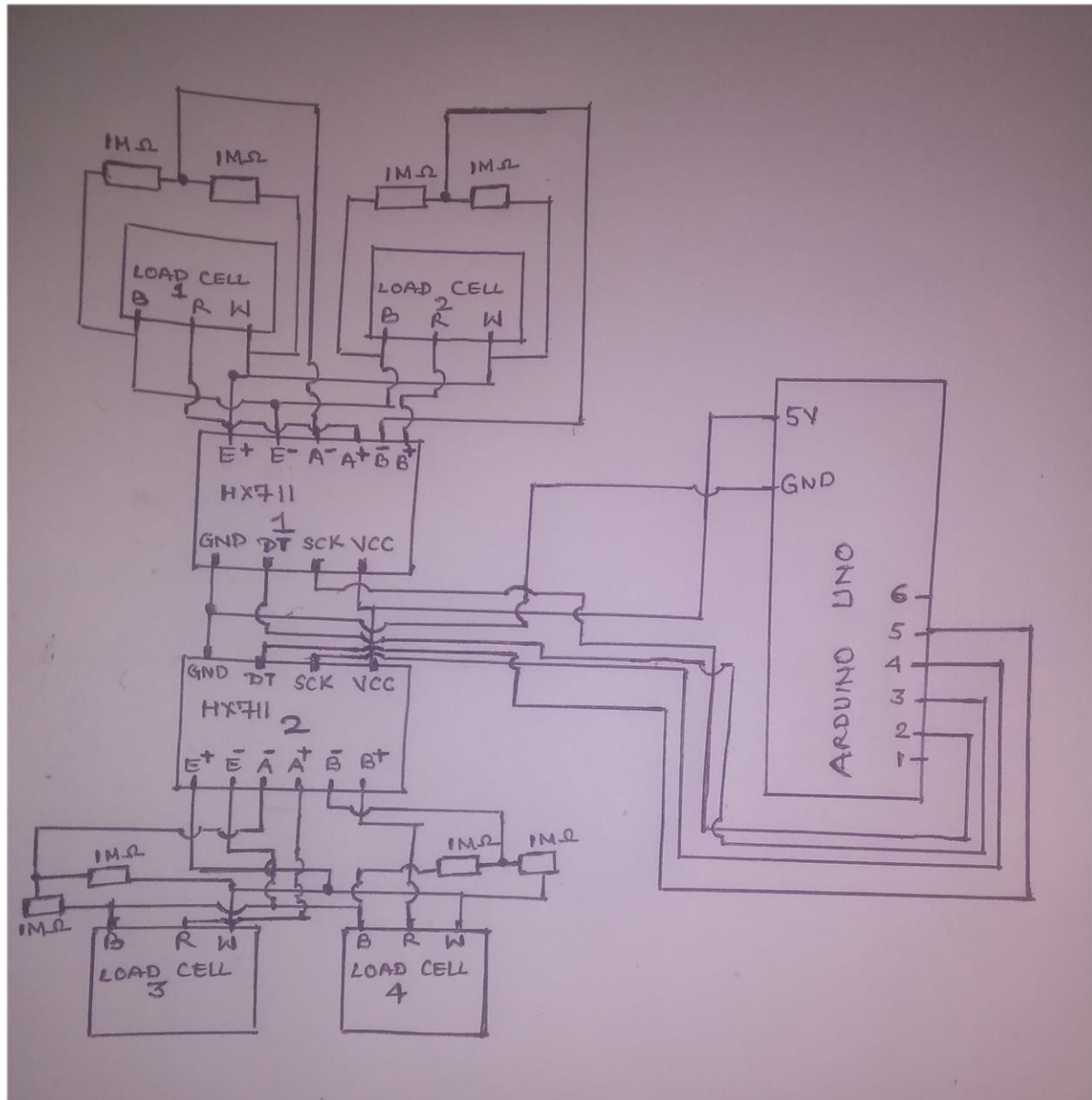


Figure 3.1 Circuit Diagram Of Four Load Cell Connected To Two Hx711 Amplifier & Arduino Uno

PRACTICAL CIRCUIT IMPLEMENTATION

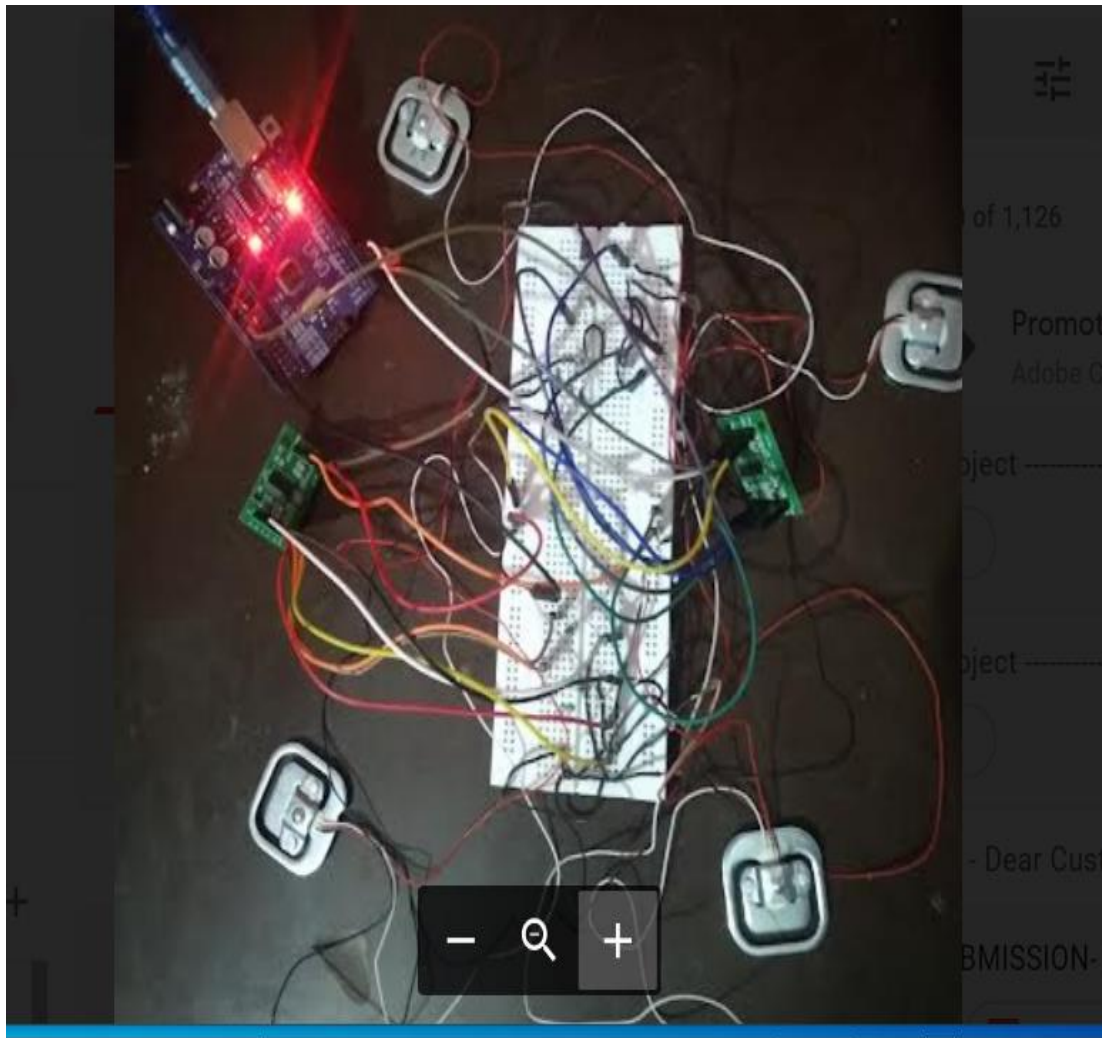


FIGURE 3.2 DISPLAY OF CIRCUITRY MADE PRACTICALLY WITH FOUR LOAD CELL

WORK PROCEDURE

Four 50 kg half bridge load sensor have been used, alongwith two hx711 load cell amplifier module and one Arduino uno. One pair of two load cell are connected to one hx711 amplifier module.

The load cell after placing some weight on it, provides analog signal which in turn converted to weight after connecting with hx711 module. This data is send to arduino which after uploading program, is proving weight display through serial monitor.

Load cell 1 has 3 wires. One white , one red & one black .the white and black wire are connected to e+ and e- of one hx711 module 1 .connecting this way will provide supply to load cell 1 . The white and black wire each individually are connected to 1 kilo ohm resistance and both further connected to a- of hx711 module 1 .The red wire of load cell1 is connected to a+ of hx711 module 1.

Load cell 2 has 3 wires. One white , one red & one black .the white and black wire are connected to e+ and e- of one hx7ii module 1 .connecting this way will provide supply to load cell 2 . The white and black wire each individually are connected to 1 kilo ohm resistance and both further connected to a- of hx711 module 1 .the red wire of load cell1 is connected to a+ of hx711 module 1.

Load cell 3 has 3 wires . One white , one red & one black .the white and black wire are connected to e+ and e- of one hx7ii module 2 .connecting this way will provide supply to load cell 3 . The white and black wire each individually are connected to 1 kilo ohm resistance and both further connected to a- of hx711 module 2 . The red wire of load cell1 is connected to a+ of hx711 module2.

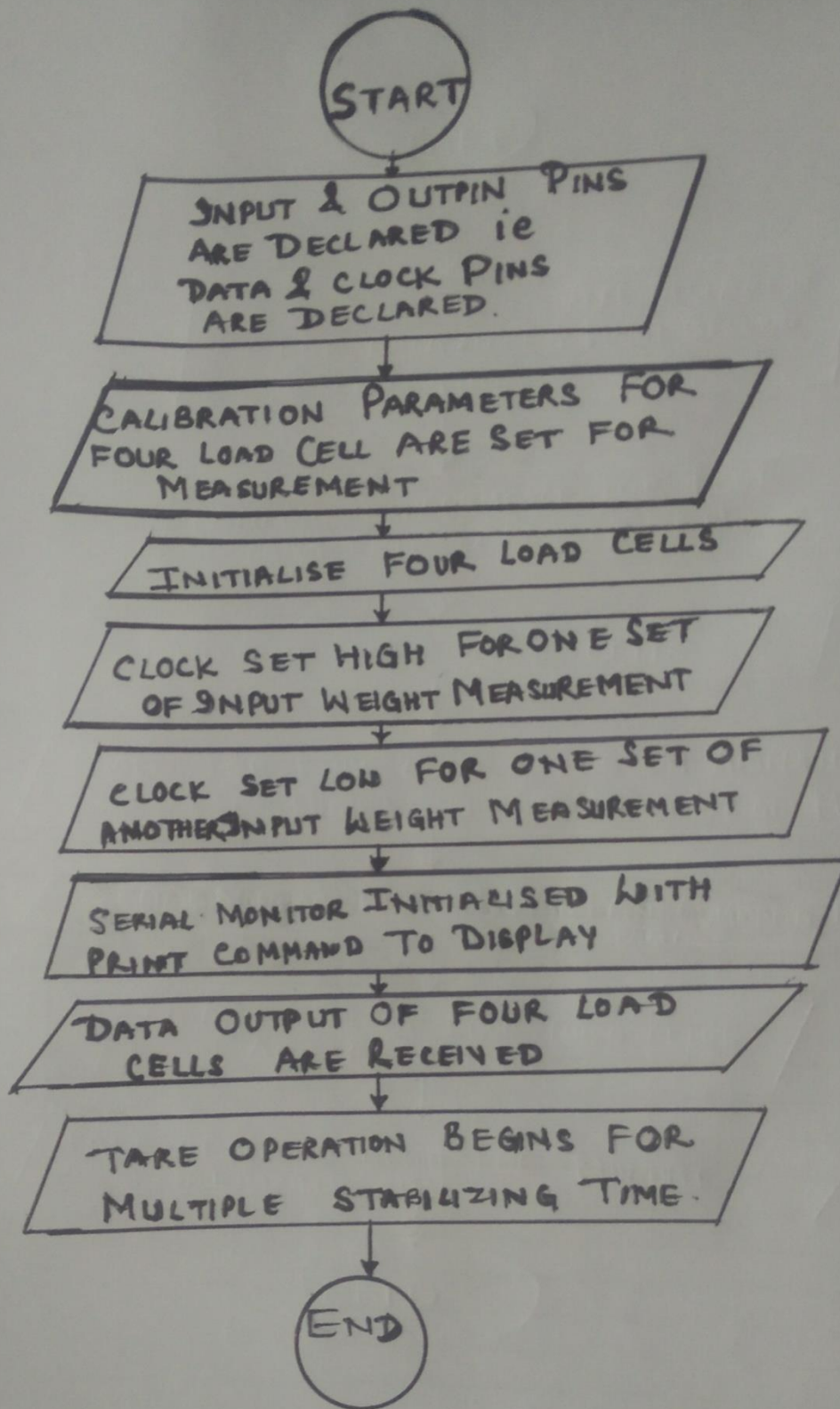
Load cell 4 has 3 wires . One white , one red & one black .the white and black wire are connected to e+ and e- of one hx7ii module 2 .connecting this way will provide supply to load cell 4 . The white and black wire each individually are connected to 1 kilo ohm resistance and both further connected to a- of hx711 module 2. The red wire of load cell1 is connected to a+ of hx711 module2.

The hx711 module has been provided with vcc , ground , dt and sck pins on board . The vcc and ground are for power supply to the module of 5 volt fromarduino kit. The dt is the data in weight converted by module after receiving analog signal from load cell .Since two load cells are connected to one hx711 , the sck pin which is a clock pin provides output ot two load cells simultaneously with clock up and down.

The VCC and ground of both hx711 are connected to VCC and ground of Arduino UNO for supply .the sck and dt pin of hx711 module 1 is connected to 2 and 3 number pin on arduino and the sck and dt pin of hx711 module 2 is connected to 5 and 6 number pin on arduino.

The program is uploaded on arduino from hx711 library with required changes and output of four load cells in weight is obtained through serial monitor.

FLOW CHART



CHAPTER 4

RESULTS AND DISCUSSIONS

This work finishes at making required circuitry, compiling and executing program and uploading it to Arduino. The four weights thus obtained from different part of foot.

CHAPTER 5

CONCLUSIONS

In this project, the system is designed and developed for measurement of weight at different points of the foot. It is dependent on body posture, deformities in the foot or leg, etc. After obtaining four weights from four nodal points on base of the foot from the subject (male/female), the weight distribution thus obtained would be compared with the normal and healthy person (male/female). Hence this foot weight distribution will help in ergonomic design of shoe.

FUTURE SCOPE

Deep learning through MATLAB, we would be able to depict the deficiency of subject thereby estimating the type of disease in subject and also required remedy to cure it. Also after witnessing the uneven weight distribution of the subject, the design of the shoe could be altered to obtain normalized weight distribution.

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3. Ms. D .Sudarvizhi¹, M. Nivetha², P. Priyadharshini³ , J.R. Swetha⁴ ¹Professor, Dept of electronics and communication, KPR institute of engineering and technology, Tamilnadu, India ^{2 3 4}Students, Dept of electronics and communication, KPR institute of engineering and technology, Tamilnadu, India , Research on IDENTIFICATION AND ANALYSIS OF FOOT ULCERATION USING LOAD CELL TECHNIQUE, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 03 | Mar 2019 www.irjet.net p-ISSN: 2395-0072 © 2019, IRJET

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APPENDIX

APPENDIX A: - Figures

Figure 1 ARDUINO UNO

Figure 2 HX711 Load Cell Amplifier Module

Figure 3 HX711 PINOUT DIAGRAM

Figure 4 50KG HALF-BRIDGE EXPERIMENTS BODY SCALE LOAD CELL SENSOR

APPENDIX B: - Program & Output

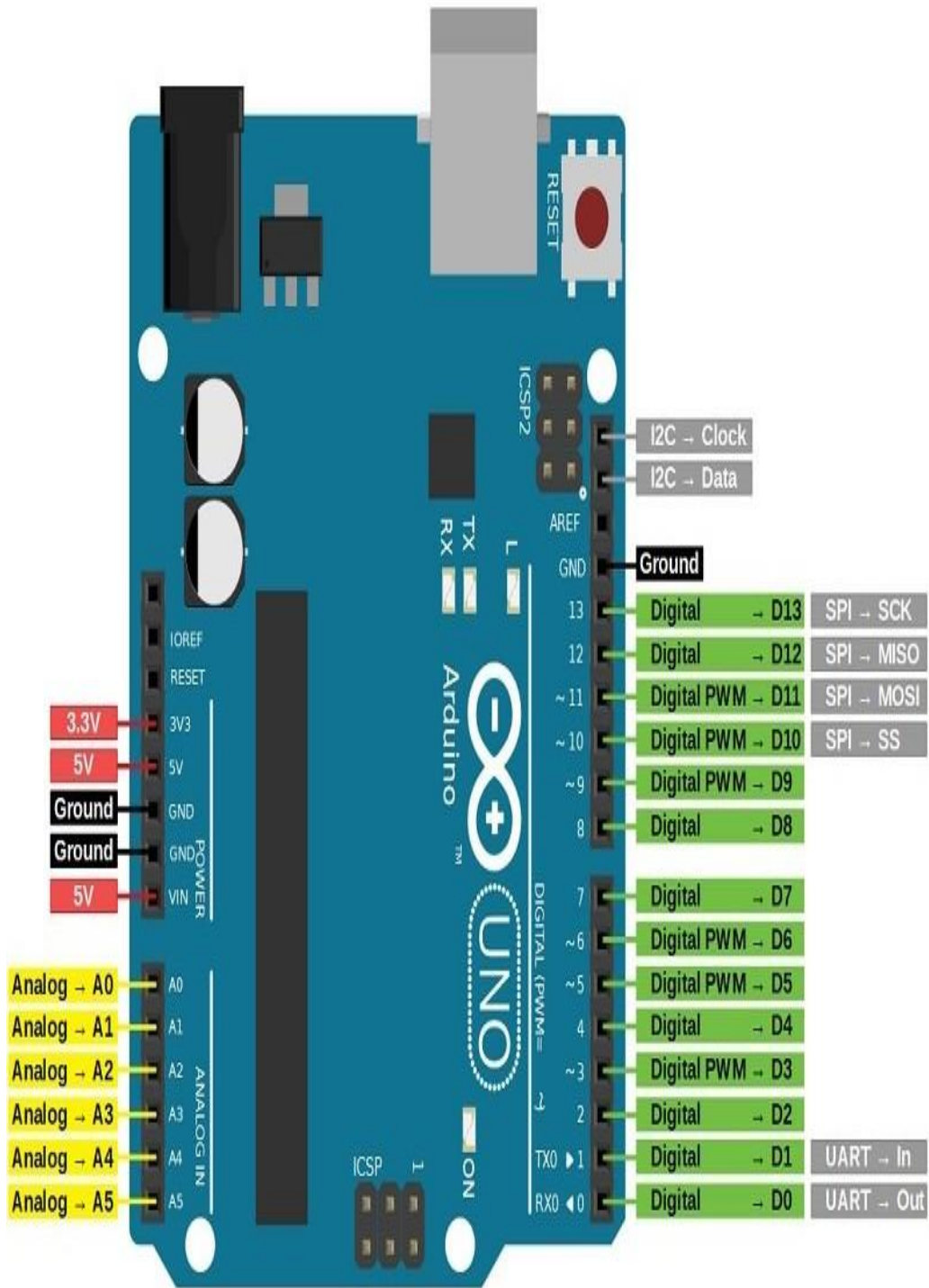


FIGURE 1:- ARDUINO UNO

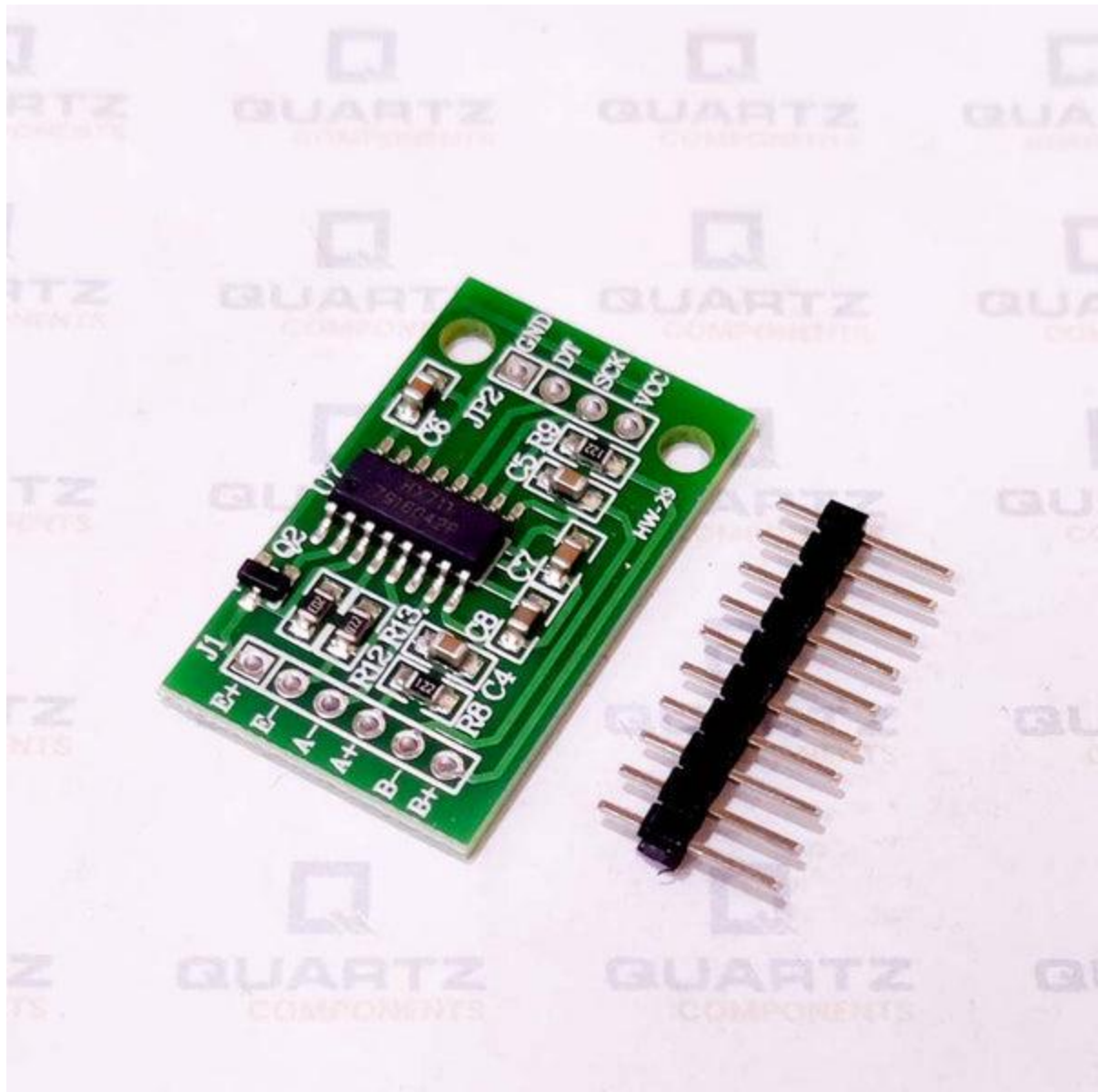


FIGURE 2:- HX711 Load Cell Amplifier Module

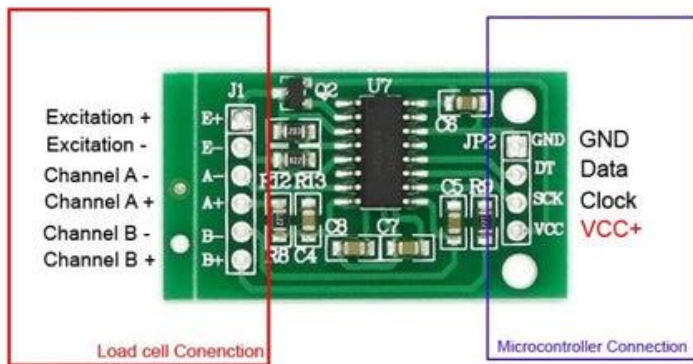


FIGURE 3 :- HX711 PINOUT DIAGRAM



FIGURE 4 :- 50KG HALF-BRIDGE EXPERIMENTS BODY SCALE LOAD CELL SENSOR

PROGRAM FOR ARDUINO

PROGRAM (Read 4X Load Cell)

// HX711_ADC.h

// Arduino master library for HX711 24-Bit Analog-to-Digital Converter for Weigh Scales

// Olav Kallhovd sept2017

// Tested with : HX711 asian module on channel A and YZC-133 3kg load cell

// Tested with MCU : Arduino Nano


```

// This is an example sketch on how to use this library for two ore more HX711 modules

// Settling time (number of samples) and data filtering can be adjusted in the config.h file


#include <HX711_ADC.h>

#if defined(ESP8266) || defined(ESP32) || defined(AVR)

#include <EEPROM.h>

#endif


//pins:

constint HX711_dout_1 = 3; //mcu> HX711 no 1 dout pin
constint HX711_sck_1 = 2; //mcu> HX711 no 1 sck pin
constint HX711_dout_2 = 5; //mcu> HX711 no 2 dout pin
constint HX711_sck_2 = 4; //mcu> HX711 no 2 sck pin


//HX711 constructor (dout pin, sck pin)

HX711_ADC LoadCell_1(HX711_dout_1, HX711_sck_1); //HX711 1
HX711_ADC LoadCell_2(HX711_dout_1, HX711_sck_1); //HX711 1
HX711_ADC LoadCell_3(HX711_dout_2, HX711_sck_2); //HX711 2
HX711_ADC LoadCell_4(HX711_dout_2, HX711_sck_2); //HX711 2


constint calVal_eepromAdress_1 = 0; // eepromadress for calibration value load cell 1 (4 bytes)
constint calVal_eepromAdress_2 = 4; // eepromadress for calibration value load cell 2 (4 bytes)
constint calVal_eepromAdress_3 = 8; // eepromadress for calibration value load cell 3 (4 bytes)
constint calVal_eepromAdress_4 = 12; // eepromadress for calibration value load cell 4 (4 bytes)

unsigned long t = 0;

```

```

void setup() {

    Serial.begin(115200); delay(10);

    Serial.println();

    Serial.println("Starting...");


    float calibrationValue_1; // calibration value load cell 1

    float calibrationValue_2; // calibration value load cell 2

    float calibrationValue_3; // calibration value load cell 3

    float calibrationValue_4; // calibration value load cell 4


    calibrationValue_1 = 696.0; // uncomment this if you want to set this value in the sketch

    calibrationValue_2 = 733.0; // uncomment this if you want to set this value in the sketch

    calibrationValue_3 = 770.0; // uncomment this if you want to set this value in the sketch

    calibrationValue_4 = 807.0; // uncomment this if you want to set this value in the sketch

    #if defined(ESP8266) || defined(ESP32)

        //EEPROM.begin(512); // uncomment this if you use ESP8266 and want to fetch the value from
        eeprom

    #endif

    EEPROM.get(calVal_eepromAdress_1, calibrationValue_1); // uncomment this if you want to fetch
    the value from eeprom

    EEPROM.get(calVal_eepromAdress_2, calibrationValue_2); // uncomment this if you want to fetch
    the value from eeprom

    EEPROM.get(calVal_eepromAdress_3, calibrationValue_3); // uncomment this if you want to fetch
    the value from eeprom

    EEPROM.get(calVal_eepromAdress_4, calibrationValue_4); // uncomment this if you want to fetch
    the value from eeprom

```

```
LoadCell_1.begin();
```

```
LoadCell_2.begin();
```

```
LoadCell_3.begin();
```

```
LoadCell_4.begin();
```

```
unsigned long stabilizingtime = 4000; // tare preciscion can be improved by adding a few seconds of  
stabilizing time
```

```
boolean _tare = true; //set this to false if you don't want tare to be performed in the next step
```

```
byte loadcell_1_rdy = 0;
```

```
byte loadcell_2_rdy = 0;
```

```
byte loadcell_3_rdy = 0;
```

```
byte loadcell_4_rdy = 0;
```

```
while (loadcell_1_rdy + loadcell_2_rdy+ loadcell_3_rdy+ loadcell_4_rdy < 4) { //run startup,  
stabilization and tare, both modules simultaneously
```

```
if (!loadcell_1_rdy) loadcell_1_rdy = LoadCell_1.startMultiple(stabilizingtime);
```

```
if (!loadcell_2_rdy) loadcell_2_rdy = LoadCell_2.startMultiple(stabilizingtime);
```

```
if (!loadcell_3_rdy) loadcell_3_rdy = LoadCell_3.startMultiple(stabilizingtime);
```

```
if (!loadcell_4_rdy) loadcell_4_rdy = LoadCell_4.startMultiple(stabilizingtime);
```

```
}
```

```
if (LoadCell_1.getTareTimeoutFlag()) {
```

```
Serial.println("TareTimeout, check MCU>HX711 no.1 wiring and pin designations");
```

```
}
```

```

if (LoadCell_2.getTareTimeoutFlag()) {

Serial.println("TareTimeout, check MCU>HX711 no.1 wiring and pin designations");

}

if (LoadCell_3.getTareTimeoutFlag()) {

Serial.println("TareTimeout, check MCU>HX711 no.2 wiring and pin designations");

}

if (LoadCell_4.getTareTimeoutFlag()) {

Serial.println("TareTimeout, check MCU>HX711 no.2 wiring and pin designations");

}


LoadCell_1.setCalFactor(calibrationValue_1); // user set calibration value (float)
LoadCell_2.setCalFactor(calibrationValue_2); // user set calibration value (float)
LoadCell_3.setCalFactor(calibrationValue_3); // user set calibration value (float)
LoadCell_4.setCalFactor(calibrationValue_4); // user set calibration value (float)

Serial.println("Startup + tare is complete");

}

void loop() {

LoadCell_1.update();

LoadCell_2.update();

LoadCell_3.update();

LoadCell_4.update();


if (millis() > t + 2000) {

float a = LoadCell_1.getData();

float b = LoadCell_2.getData();

```

```

float c = LoadCell_3.getData();

float d = LoadCell_4.getData();


Serial.print("Load_cell 1 output val: ");

Serial.println(a);

Serial.print("Load_cell 2 output val: ");

Serial.println(b);

Serial.print("Load_cell 3 output val: ");

Serial.println(c);

Serial.print("Load_cell 4 output val: ");

Serial.println(d);

Serial.print("total weight :");

Serial.println(a+b+c+d);

    t = millis();

}

```

// receive command from serial terminal, send 't' to initiate tare operation:

```

if (Serial.available() > 0) {

floati;

charinByte = Serial.read();


if (inByte == 't') {

    LoadCell_1.tareNoDelay();}

}

if (Serial.available() > 0) {

```

```

floati;

charinByte = Serial.read();

if (inByte == 't') {
    LoadCell_2.tareNoDelay();}

}

if (Serial.available() > 0) {

floati;

charinByte = Serial.read();

if (inByte == 't') {
    LoadCell_3.tareNoDelay();}

}

if (Serial.available() > 0) {

floati;

charinByte = Serial.read();

if (inByte == 't') {
    LoadCell_4.tareNoDelay();}

}

//check if last tare operation is complete
if (LoadCell_1.getTareStatus() == true) {
Serial.println("Tare load cell 1 complete");

}

```

```
if (LoadCell_2.getTareStatus() == true) {  
    Serial.println("Tare load cell 2 complete");  
}  
if (LoadCell_3.getTareStatus() == true) {  
    Serial.println("Tare load cell 3 complete");  
}  
if (LoadCell_4.getTareStatus() == true) {  
    Serial.println("Tare load cell 4 complete");  
}  
}
```

OUTPUT

```
Starting...
TareTimeout, check MCU>HX711 no.1 wiring and pin designations
TareTimeout, check MCU>HX711 no.2 wiring and pin designations
Startup + tare is complete
Load_cell 1 output val: nan
Load_cell 2 output val: nan
Load_cell 3 output val: nan
Load_cell 4 output val: nan
total weight :nan
Tare load cell 1 complete
Tare load cell 3 complete
Load_cell 1 output val: nan
Load_cell 2 output val: nan
Load_cell 3 output val: nan
Load_cell 4 output val: nan
total weight :nan
Tare load cell 4 complete
Load_cell 1 output val: nan
Load_cell 2 output val: nan
Load_cell 3 output val: nan
Load_cell 4 output val: nan
total weight :nan
Tare load cell 2 complete
Load_cell 1 output val: nan
```