ELP 305: Design and Systems Lab

Week 2 Report

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Submitted to: Prof. Subrat Kar
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Week 2 Report: Requirements + Specifications

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Body

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List of Abbreviations (to be updated)

Table 1. Some Abbreviations

Abbreviation	**Stands for**
IF	Involvement Factor
ID	Identification
CPCB	Central Pollution Control Board
mg	milligram
AC	Alternating Current
dB	Decibels
Kg	Kilograms
ABS	Acrylonitrile Butadiene Styrene

Index ? at end with pg no. ?

Glossary??

Mind Map

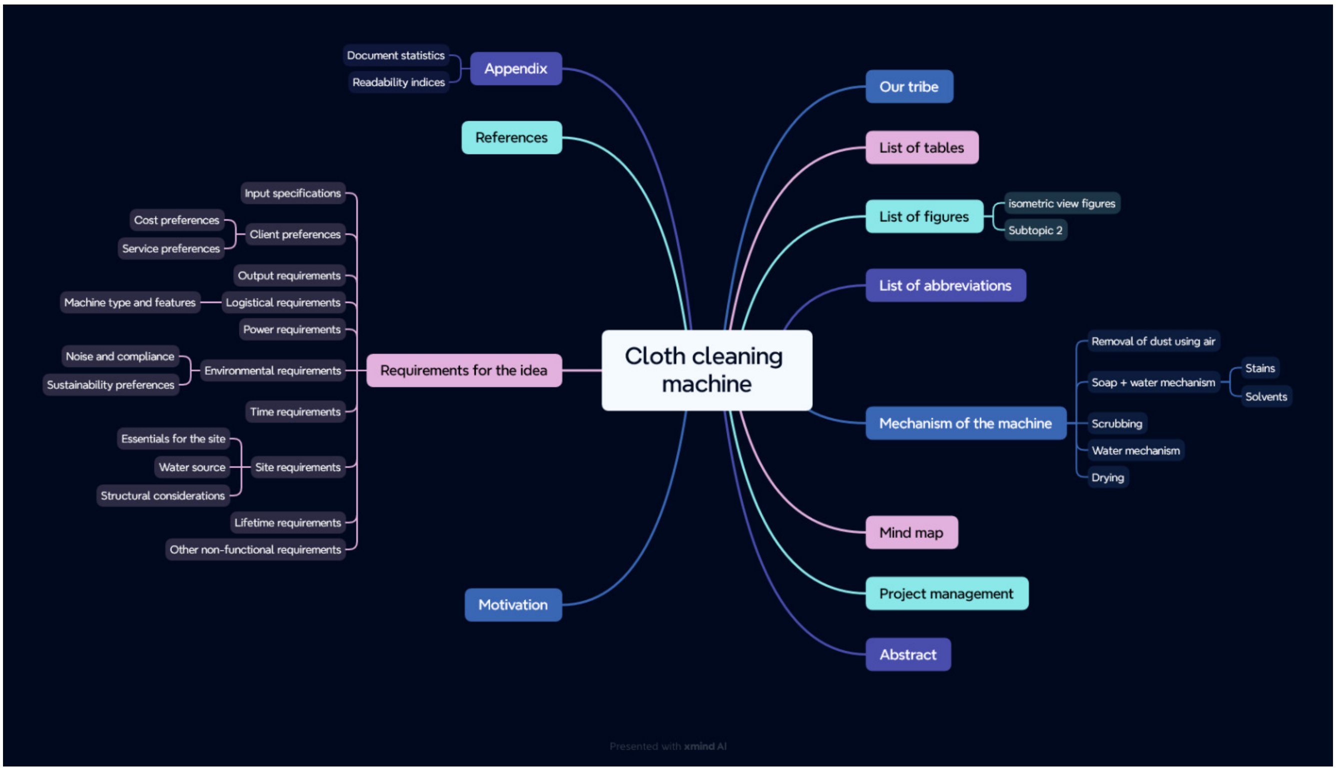


Figure 1. Outline Mind Map

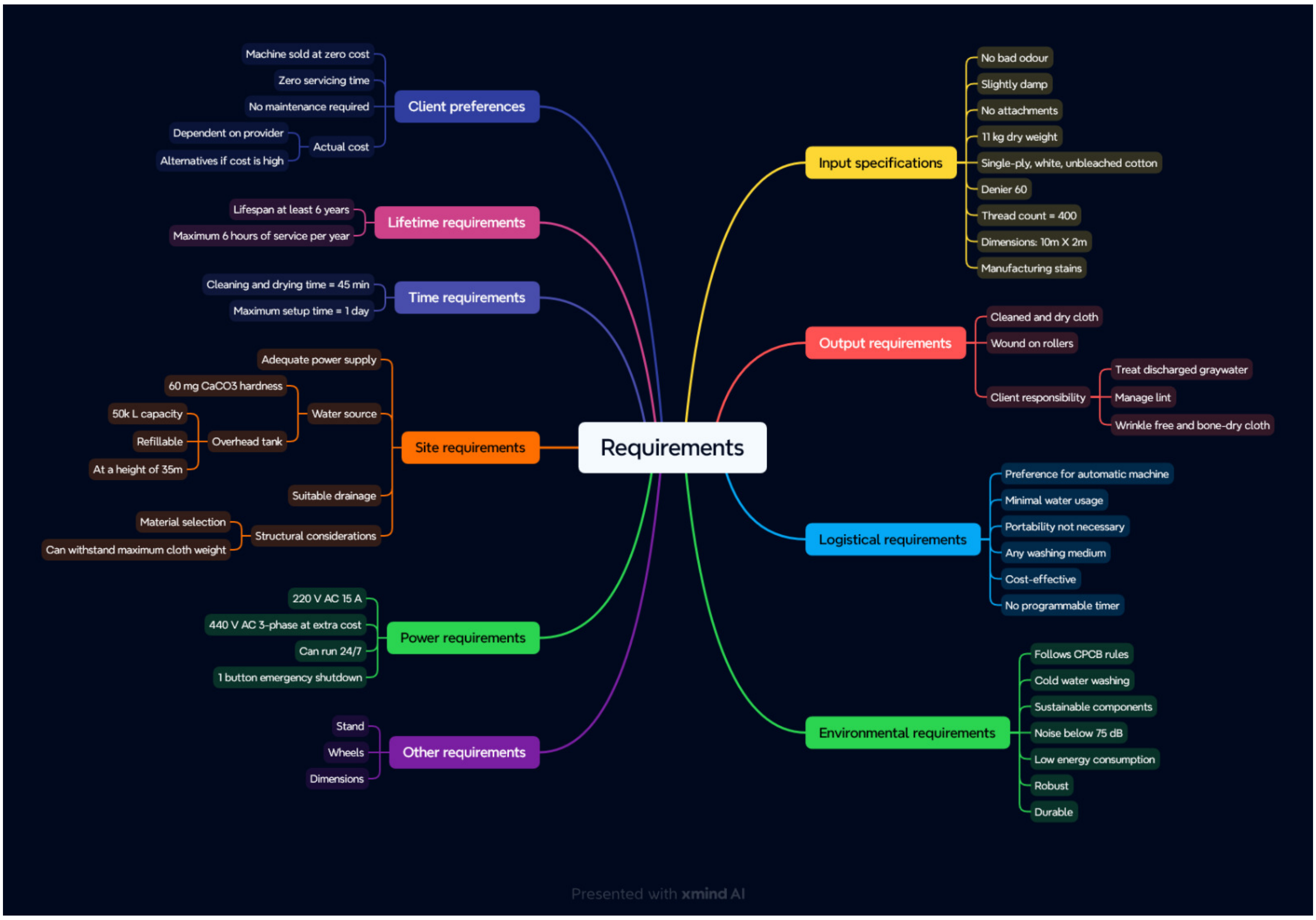


Figure 2. Requirements Mind Map

Project Management

- Network Chart
- WBS
- Gantt Chart
- Resource Breakdown

Abstract

This project revolves around developing a user-centric washing machine, *which involves a comprehensive analysis of the features an average user looks for. Through extensive research, we will identify key elements that resonate with the needs and preferences of the general population when searching for a washing machine.*
Our initial design focuses on building a basic model, which in further iterations can incorporate more advanced features as a result of extensive surveys and research done across the course of the project to satisfy the contemporary users' needs.

Motivation ? edit acc to ques given

Our motivation for developing this innovative washing machine stems from a desire to redefine the conventional norms in the industry. We aim to go beyond the traditional boundaries and create a product that caters to the diverse needs of the broad market. Our product will heavily rely on user feedback at each stage of the design, making it user-friendly to ensure that our product becomes very accessible. This model is committed to going above and beyond the ordinary, surpassing user expectations, and setting new benchmarks in washing machine technology. We believe in creating a product that not only fulfills practical needs but also enhances the overall user experience, elevating the standard for what a washing machine can achieve.

Mechanism of the Machine

Removal of Dust using Air

To secure the cloth in place and prevent it from being carried away by the wind, lay it flat and affix it to the surface. Utilize an air blower by directing the airflow over the cloth, with the attached blower expelling air from the top onto the fabric. For smaller pieces of fabric, a 500W mini blower, priced at Rs 500, is an effective solution. Alternatively, a manual approach involves installing a high-speed fan within a pipe for a similar effect.

Soap + Water Mechanism

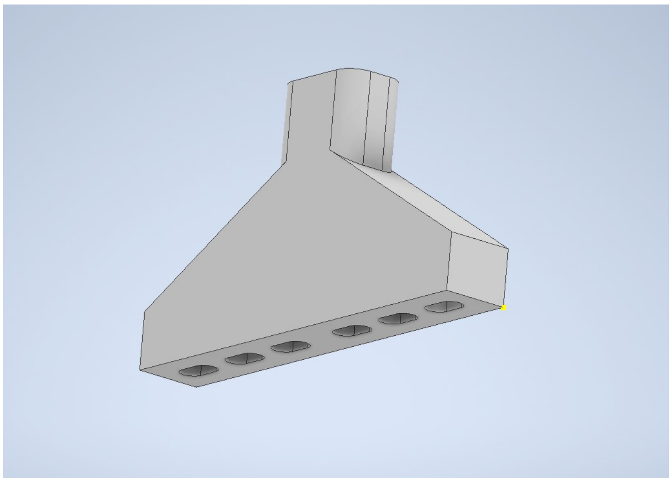


Figure 3. Isometric view of Sprinkler

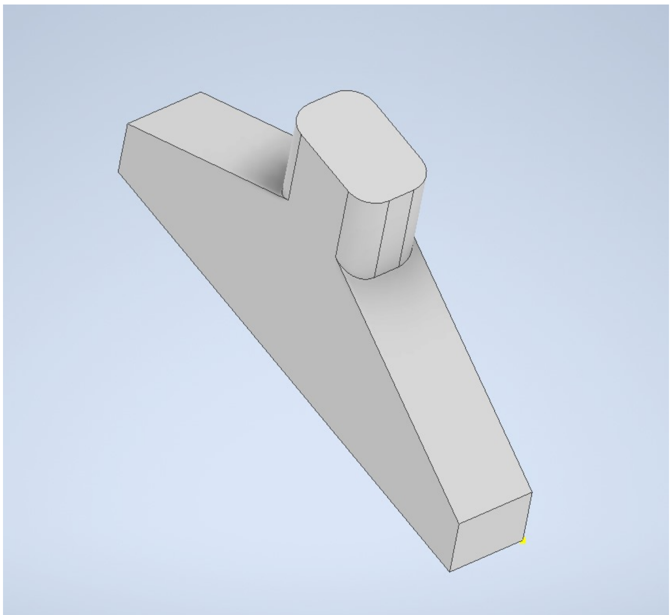


Figure 4. Isometric view of Sprinkler

The fundamental concept behind this method is to ensure comprehensive cleaning by spreading the soap solution evenly on both sides of the fabric. To execute this, a soap solution is meticulously prepared above the targeted cloth. This solution with a predetermined ratio of soap to water facilitates effective cleansing. Employing a specialized nozzle mechanism, the soap solution is methodically sprinkled onto the fabric evenly in both directions making it more effective in removing dirt, stains. The end result comes out to be a thorough and uniform cleaning mechanism.

Stains

In our research on fabric stains encountered during the manufacturing process, we identified common culprits such as oil-based stains, dye, and rust stains. For tackling oil-based stains like grease and wax, we recommend using petroleum-based cleaning agents or robust detergents such as ABS. Paint stains can be effectively removed with turpentine or a detergent pretreatment. Rust stains, on the other hand, respond well to a combination of detergents and scrubbing. While vinegar can be used for stain removal, it may require more time, leading us to consider alternative solutions. For oil stains, a mixture of 50% water and 50% white vinegar, along with a hot water detergent solution, proves effective. Spot cleaning for odors and stains can be achieved using a solution of white vinegar and water or a paste of baking soda and water. Bleaching, if needed, can be accomplished with bleaching powder, although caution is advised to prevent potential damage to the fabric fibers. Our comprehensive approach addresses various stains, providing practical solutions for effective cloth cleaning in the manufacturing process.

Solvents

In our exploration of stain removal methods, we categorized stains into organic and inorganic types. Organic stains, such as those absorbed from lubricating oil, dyes, grease, and tannin, respond well to organic solvents. These solvents, such as ABS , effectively target and break down organic compounds, making them suitable for various manufacturing stains. On the other hand, inorganic stains, including adsorbed substances like muddy soil, inorganic salts, and contaminants, require a different approach. For these stains, the use of non-polar and volatile solvents is recommended, ensuring efficient removal without leaving residues. Additionally, high-pressure jet machines prove effective in the scouring process, providing a thorough cleaning method for a range of stains. This comprehensive strategy incorporates specialized solvents and techniques tailored to address the diverse nature of stains encountered in the manufacturing of fabrics.

Scrubbing

For a washing machine assembly line, we've prioritized effective scrubbing for optimal cloth cleaning. Recognizing the fabric's thickness, we've implemented a two-step scrubbing approach. As the cloth advances between the conveyor belts, a circular scrubber is strategically positioned to vigorously scrub one side. To enhance the scrubbing effectiveness, we've incorporated a rough platform opposite to the scrub, acting like a 'washboard' for improved friction and cleaning. This meticulous scrubbing process is crucial, as without the platform, the scrubbing efficiency is compromised. After cleaning one side, we reverse the positions of the scrubber and platform to ensure a thorough scrubbing action on the other side. Our design emphasizes the importance of robust scrubbing for a comprehensive and efficient cleaning process on the assembly line.

Water Mechanism

The scrubbed fabric retaining traces of soap, undergoes exposure to high-pressure water from a nozzle. Subsequently, the cloth is guided through a wiper to eliminate any surplus moisture and soap solution. The combined unit, comprising both the nozzle and wiper, moves back and forth across the fabric for several iterations, with the exact number determined during the testing phase.

Drying

The device produces warm air directed towards damp surfaces using a hot air-drying method. The same mechanism can be understood as the one used in a hair dryer. This targeted application of heat speeds up the evaporation process of water molecules. The elevated temperature boosts the energy of the water, facilitating its swift transition from liquid to vapor. This mechanism effectively eliminates moisture, making it a fast and efficient technique for drying fabrics.

Requirements for the Idea

Input Specifications

- **Material Specifications:** Newly manufactured white unbleached cotton with single-ply, Denier 60, and a thread count 400.
- **Dimensions:** 10 meters in length and 2 meters in width.
- **Cloth Characteristics:** Free from foul odour, slightly damp, and without buttons, zippers, or attachments.
- **Cleaning Limitations:** Maximum weight for cleaning is set at 11 kg dry, with stains limited to those occurring during manufacturing.
- **Cost and Service Preferences:** Preference for the washing machine to be offered at zero cost, requiring no servicing time and no maintenance. Actual prices are expected to depend on the provider, with alternatives considered if costs are excessively high.

Outputs Requirements

- **Desired Output:** A cleaned and dry cloth wound on rollers.
- **Client Responsibilities:** Treating discharged graywater, managing lint, and ensuring the returned cloth is wrinkle-free and bone-dry.

Power Requirements

- **Voltage and Phase Requirements:** The washing machine should operate on 220VAC 15A, with the option for 440VAC 3-phase available at an additional cost.
- **Operational Expectations:** They are expected to run continuously, 24/7, with an emergency shutdown initiated using a 1-button process.

Logistical Requirements

- **Machine Type and Features:** An automatic washing machine is preffered with minimal water usage and no need for portability or a programmable timer.
- **Washing Medium Features** There are no restrictions on the washing medium, but costs may be incurred for using rare solvents, focusing on overall cost-effectiveness.

Environmental Requirements

- **Noise Restrictions:** Noise levels should not exceed 75 dB.
- **Compliance:** Must comply with local regulations, including those set by the Central Pollution Control Board (CPCB).
- **Sustainability Preferences:** Preference for cold water washing, sustainable components, and optimization of energy consumption, robustness, and durability.

Site Requirements

- **Essentials for the Site:** Adequate power supply, suitable drainage, and specific design parameters.
- **Water Source:** The water source was specified as having 60 mg CaCO3/l hardness, with an overhead tank and a 50,000-liter refillable capacity at 35 meters.
- **Structural Considerations:** Structural considerations include material selection and the ability to withstand the maximum cloth weight.

Time Requirements

Design Time Requirements ? heading doesnt match with points ?

- **Cleaning and Drying time:** Atmost 45 minutes.
- **Use Rate:** ?
- **Setup Time:** As little time as possible, no more than 1 day.

Time to Market Requirements

Lifetime Requirements

- **Expected Lifetime:** The machine is expected to last atlest 6 years.
- **Service Hours and Cost:** No more than 6 hours per year and there isn't an explicit cost constraint for the servicing.

End of Life Requirements

- **Replacement for Old Machine:** Client could be interested in replacing the old machine for a new one at a discounted price.
- **Parts' Availability:** Parts of the machine should be available for 10 years to enable servicing.

Other Non-Functional Requirements

- **Miscellaneous Considerations:** Dimensions and the inclusion of a stand or wheels are left to the designer's discretion.

Component Analysis

Roller

i. The roller will roll the washed cloth, coming through the conveyor belt.
ii. A controlled DC motor will be used to drive the roller.
iii. Appropriately select the dimensions of the roller, like the diameter of the roller and its length, based on the conveyor width.
iv. Choose a proper outer covering for the roller, which can provide a better grip and friction for

the cloth.

The cloth will also be straightened using 1 or 2 uncontrolled rolling cylinders which can provide the requisite tension in the fabric and guide the fabric onto the roller.

Figure 5. Industrial Roller

<u>Controlling DC motor using Arduino:</u>

To control the speed of a DC motor using Arduino, we need to adjust the input voltage supplied to the motor. We can control the input voltage with a pulse-width modulated (PWM) signal. To change the speed of the DC motor we need to change the amplitude of the input voltage that is applied to the motor. A common technique to do that is PWM (Pulse Width Modulation). In PWM the applied voltage is adjusted by sending a series of pulses so the output voltage is proportional pulse width generated by the microcontroller that is also known as **duty cycle**.

The higher the duty cycle, the higher the average voltage applied to the DC motor (resulting in higher speed) and the shorter the duty cycle, the lower the average voltage applied to the DC motor (resulting in lower speed).

Arduino and L293D Circuit Diagram

A common and cheap solution to drive motors and efficiently control them, is to use a Motor Controller module along with Arduino. L293D Motor driver module is a readily available IC which can be easily interfaced with Arduino, to control the various aspects of DC motors like speed, direction and braking. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36V. Below is an example of a circuit diagram to drive multiple motors from a single module, and Arduino code to interface a motor with the module.

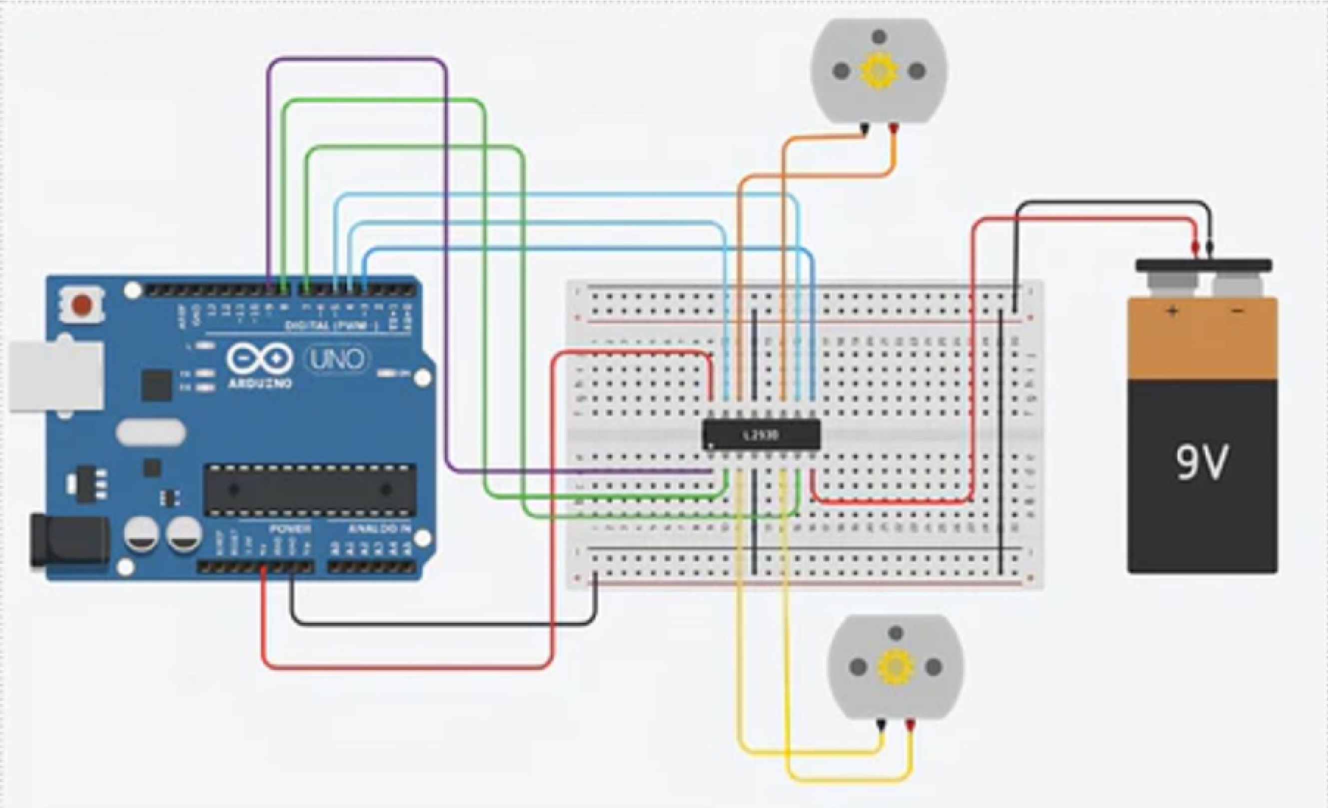


Figure 6. Circuit for Roller

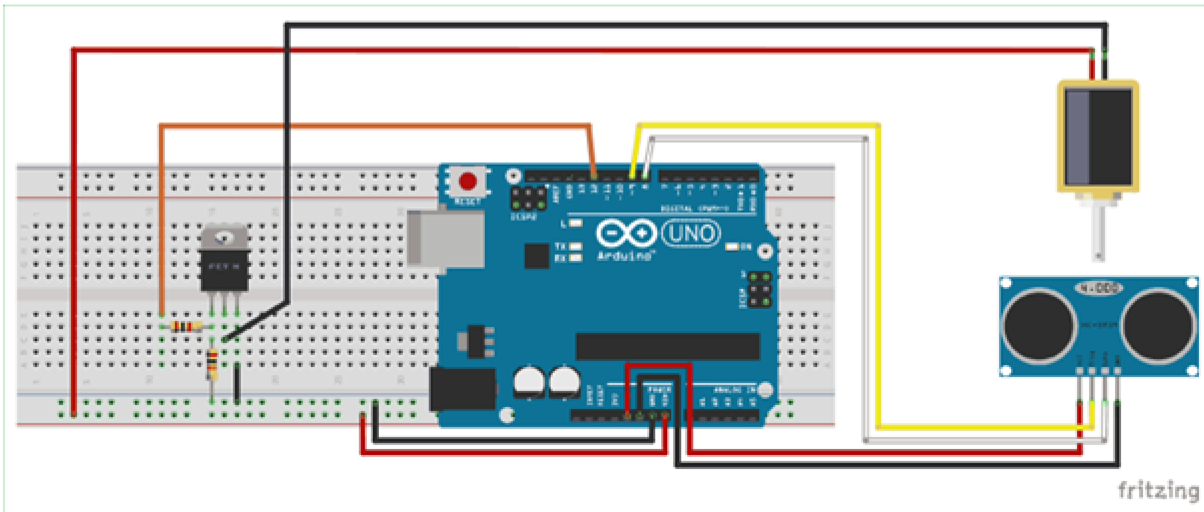
Arduino Code

```
// Motor A connections
int enA = 9;
int in1 = 8;
int in2 = 7;
// Motor B connections
int enB = 3;
int in3 = 5;
int in4 = 4;

void setup() {
  // Set all the motor control pins to outputs
  pinMode(enA, OUTPUT);
  pinMode(enB, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);

  // Turn off motors - Initial state
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

void loop() {
```

```
  directionControl();
  delay(1000);
  speedControl();
  delay(1000);
}

// This function lets you control the spinning direction of motors
void directionControl() {
  // Set motors to maximum speed
  // For PWM maximum possible values are 0 to 255
  analogWrite(enA, 255);
  analogWrite(enB, 255);

  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);

  delay(2000);

  // Now change motor directions
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);

  delay(2000);

  // Turn off motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

// This function lets you control the speed of the motors
void speedControl() {
  // Turn on motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);

  // Accelerate from zero to maximum speed
  for (int i = 0; i < 256; i++) {
    analogWrite(enA, i);
    analogWrite(enB, i);
    delay(20);
  }
```

```
  // Decelerate from maximum speed to zero
  for (int i = 255; i >= 0; --i) {
    analogWrite(enA, i);
    analogWrite(enB, i);
    delay(20);
  }

  // Now turn off motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}
```

Soap Water Sprinkler

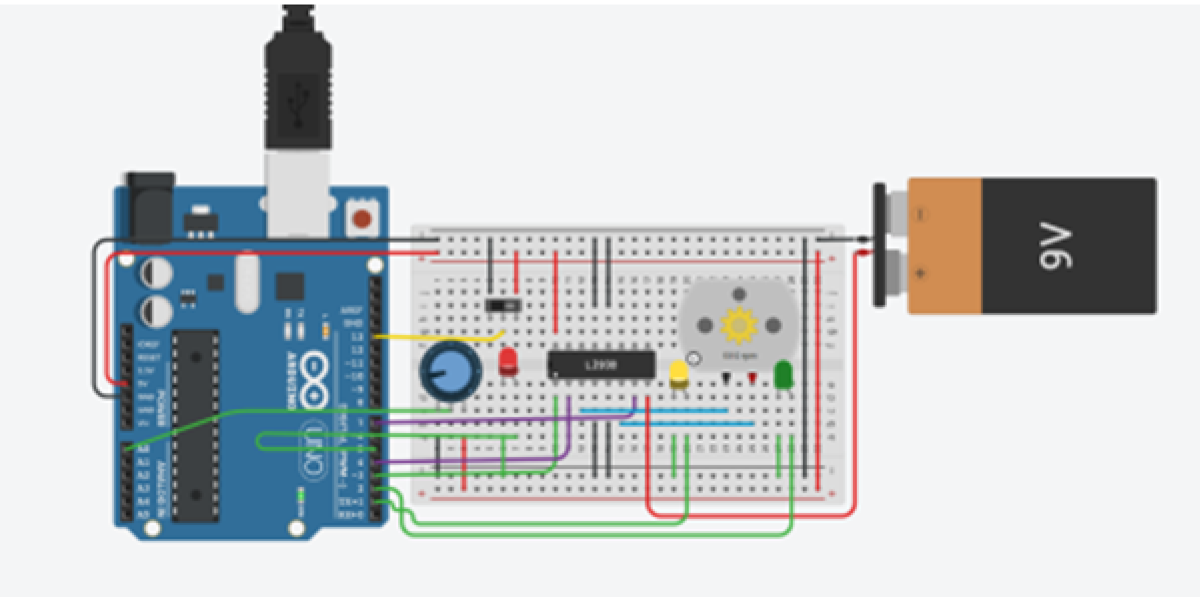


Scrubber

i. Scrubbing will occur in circular motion (clockwise/anticlockwise)

ii. Speed is controlled using electric signals (based on the voltage of a potentiometer) • Direction (clockwise/ anticlockwise) can be controlled based on a digital logic [1 or 0] • The L293D motor driver is used. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V.

iii. Multiple scrubbers/ scrubbing mode patterns can be defined on this model further based on the design specifications.

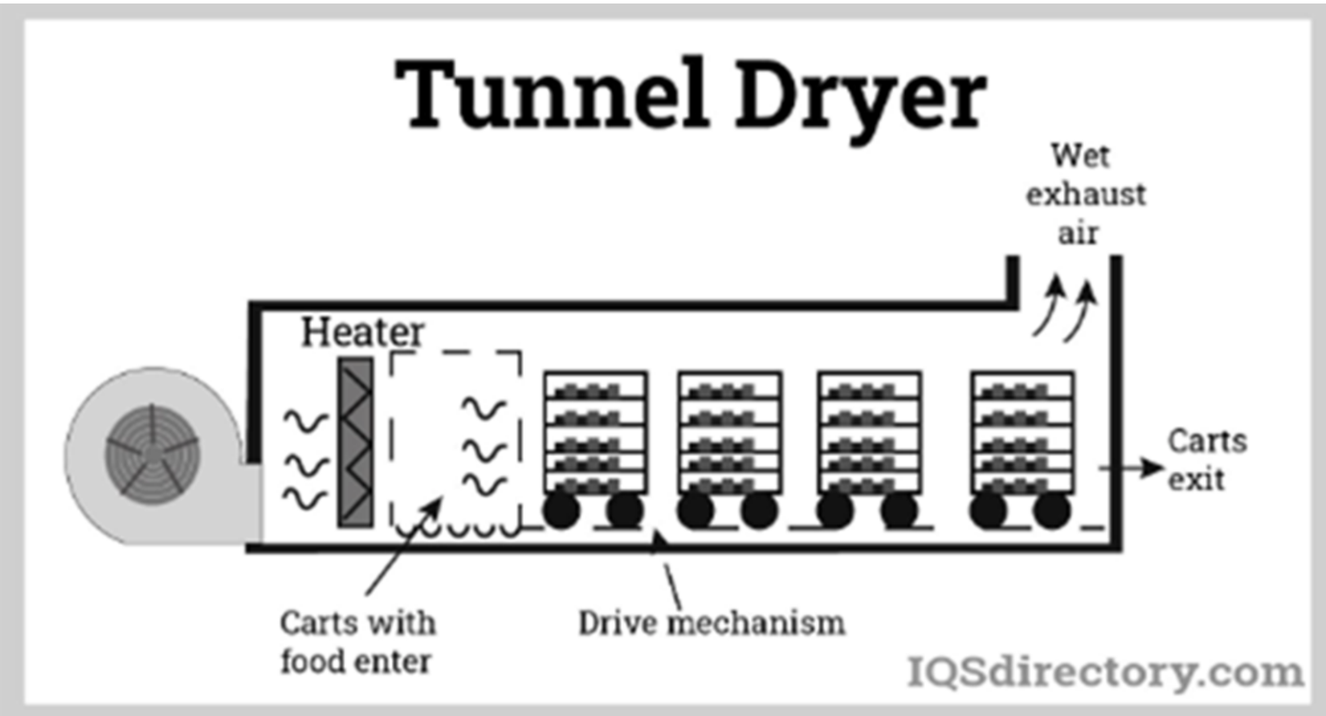



```
#define BTN_DIR 13
#define POT 0
#define EN1 3
#define M1A 4
#define M1B 7
#define LED_GREEN 2
#define LED_RED 5
#define LED_YELLOW 1

int pos, veloc, oldpos=-1, Speed;

void setup() {
  pinMode(M1A, OUTPUT);
  pinMode(M1B, OUTPUT);
  pinMode(LED_GREEN, OUTPUT);
  pinMode(LED_RED, OUTPUT);
  pinMode(LED_YELLOW, OUTPUT);
  pinMode(BTN_DIR, INPUT);
}

void loop() {
  pos = analogRead(POT);
  Speed = analogRead(POT);

  if (pos != oldpos) {
    veloc = map(pos, 0, 1023, 0, 255);
    Speed = map(pos, 0, 1023, 0, 255);
    analogWrite(EN1, veloc);
    analogWrite(LED_RED, Speed);
    oldpos = pos;
  }

  if (digitalRead(BTN_DIR) == LOW) {
    digitalWrite(M1A, HIGH);
```

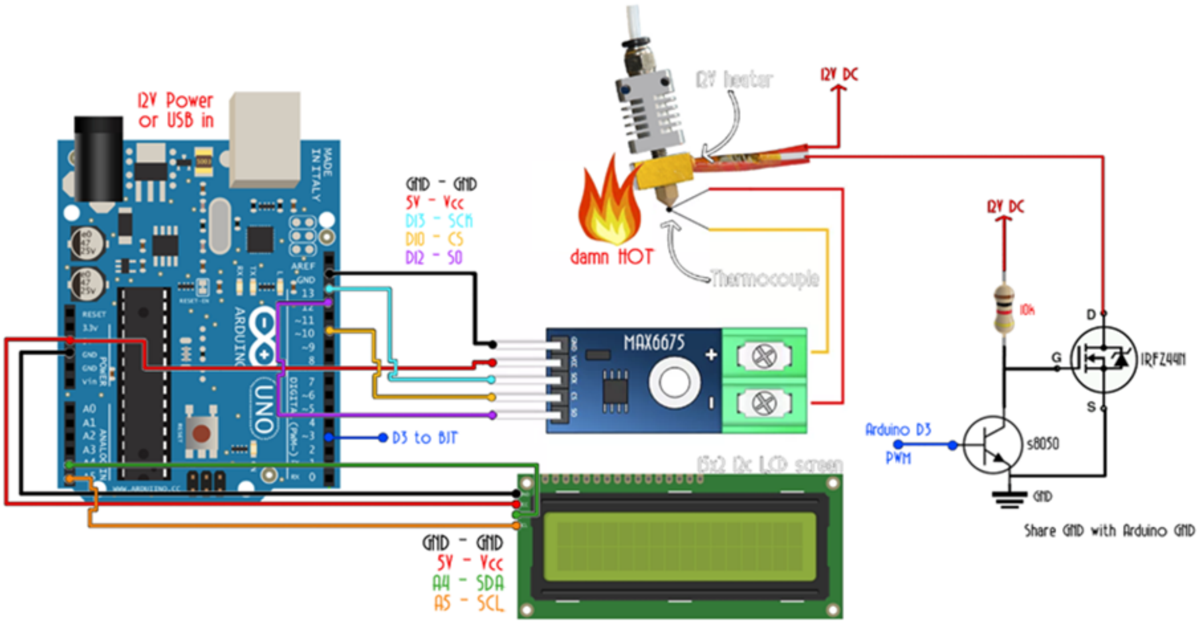
```
      digitalWrite(M1B, LOW);
      digitalWrite(LED_GREEN, HIGH);
      digitalWrite(LED_YELLOW, LOW);
    } else {
      digitalWrite(M1A, LOW);
      digitalWrite(M1B, HIGH);
      digitalWrite(LED_YELLOW, HIGH);
      digitalWrite(LED_GREEN, LOW);
    }

    delay(200);
  }
```

Dryer

We are planning to use the configuration of tunnel dryer to dry the clothes. The power and torque requirements of the motor used in blower and power requirements of the heater will depend on the time needed to dry the cloth, rate at which the cloth is being fed, width and height of the chamber, final moisture content and initial moisture content. Also, since counter current configuration is most efficient, we will be using the same in our design. Using tunnel dryers also allows us to move the conveyor belt slowly as it is very efficient in processing materials taking long drying time and thus requiring lesser motor drive.

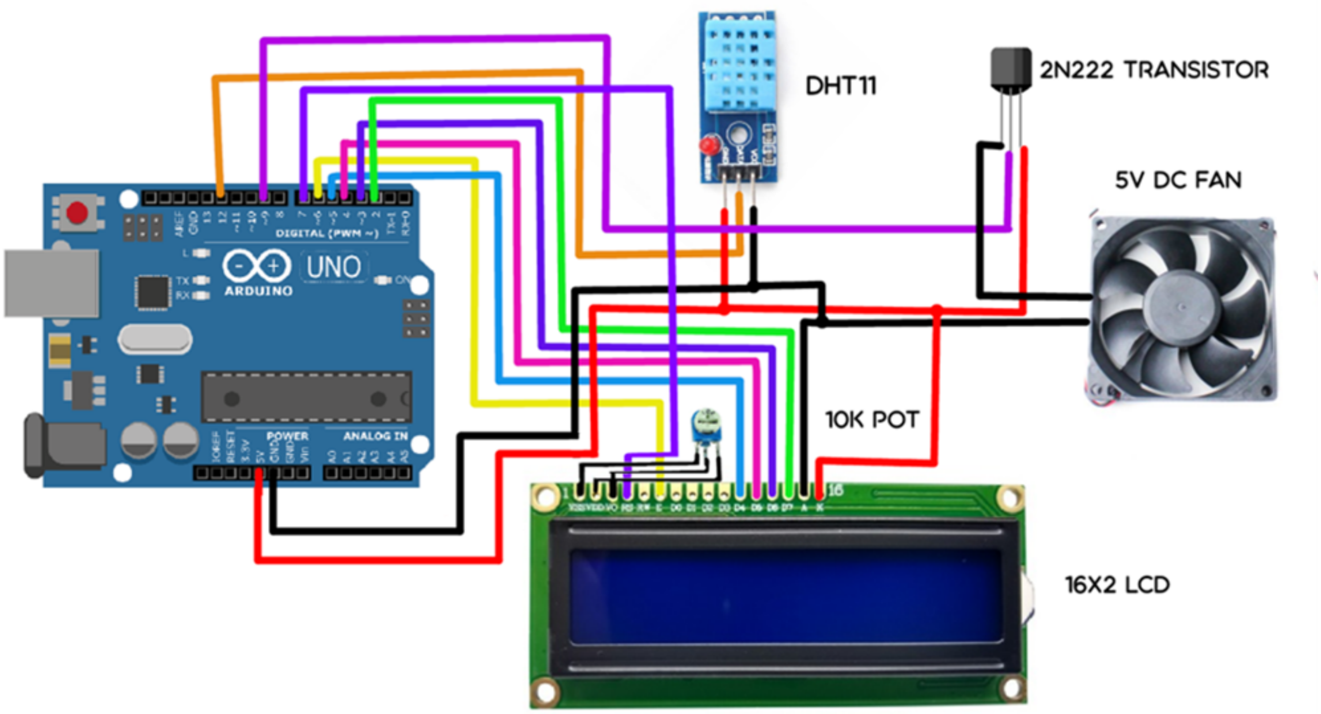


Optimisation for power requirements will be done once design specs are provided and it would be based on the mathematical modelling and simulations done to observe the humidity content with rate of air flow and power input to heater and blower. To control the heater we will use Arduino, a temperature sensor (thermocouple), a relay module, battery and bunch of connecting wires. One of the circuits which can be used is as follows:



One can have LCD display to keep track of any errors in the functioning. Arduino code for controlling heater is as follows: link: code1

For running and controlling the blower we need to have an Arduino controlling motor, anemometer, battery and bunch of wires.



The code is: link: code2

Blower

We will be controlling the speed of the DC motor using a potentiometer for the purpose of blower in our washing machine to remove heavy dust particles from the cloth piece. ... Potentiometer has three terminals. Outer two terminals are for power supply and the middle terminal is the output. ...

As we rotate the knob of the potentiometer, the resistance between the middle terminal and one of the outer terminals changes. This change in resistance controls the voltage supplied to the motor, which in turn controls its speed. … We can connect multiple DC motors in our system by making slight modifications in the wiring. … A Transistor is used for more efficient control of the motor speed. By controlling the current flow to the motor, transistors can prevent overloading and overheating, enhancing the motor's lifespan.

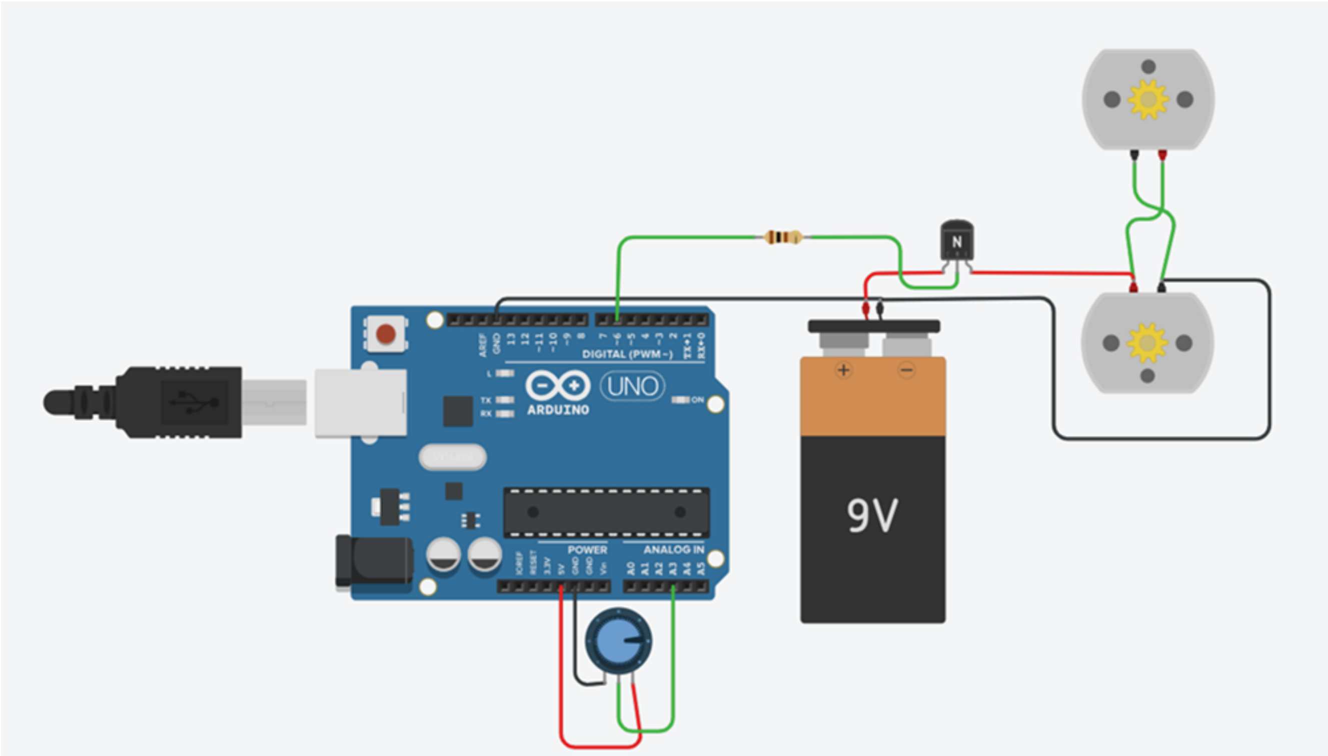


Figure 7. TinkerCAD circuit for Blower

The code is: link: code

Specifications

Energy Specifications

Space Specifications

Power Specifications

Cost Specifications

Performance Specifications

Manpower Specifications

Milestone Specifications

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Index(with pageno.)??

Glossary

ABS (Acrylonitrile Butadiene Styrene)

A strong and durable thermoplastic polymer used in manufacturing.

Affix

Securely attach or fasten.

CPCB (Central Pollution Control Board)

A regulatory body in India that sets standards for environmental pollution control.

Denier

A unit of measurement for the linear mass density of fibers. It is the mass in grams per 9000 meters of the fiber.

Desizing

The removal of sizing agents, such as starch or other chemicals, from fabrics to prepare them for further processing.

Gantt Chart

A visual representation of a project schedule that shows the start and finish dates of various elements of the project.

Graywater

Domestic wastewater that does not contain fecal matter, often reused for irrigation or other non-potable purposes.

Isometric View

A three-dimensional representation of an object, showing all three spatial dimensions in one view.

Mercerizing

A textile finishing process that increases the luster and strength of fabric, typically cotton, by treating it with a caustic soda solution.

Nozzle

A device for controlling the direction or flow of a fluid.

Nozzle mechanism

The nozzle and flapper mechanism are a displacement type detector which converts mechanical movement into a pressure signal by covering the opening of a nozzle with a flat plate called the flapper. This restricts fluid flow through the nozzle and generates a pressure signal.

Petroleum-based cleaning agents

Solvents effective for oil-based stains (e.g., mineral spirits, naphtha).

Pretreatment

Applying cleansing agent before washing.

Resource Breakdown

A breakdown of resources required for a project, often detailing labor, equipment, and materials.

Robust Scrubbing

Strong, sturdy, and effective scrubbing.

Rust stains

Formed by oxidation of iron.

Scour

To clean or rub using a stiff brush or abrasive.

Setup Time

The time required to prepare the washing machine for operation.

Singeing

The process of burning off protruding fibers or impurities from the surface of a fabric, often using a flame or hot surface.

Syrup

In the context of the report, it may refer to a concentrated solution of a sugar or sugar substitute in water.

Tannin

bitter, astringent substance found in plants.

Testing Phase

A stage in the development process where the functionality and performance are evaluated.

Thermoplastic Polymer

A type of polymer that becomes pliable or mouldable when heated and solidifies upon cooling.

Thread Count

The number of threads woven together per square inch in a fabric. A higher thread count is generally associated with a finer and more luxurious fabric.

Traces

mall amounts or remnants.

Turpentine

solvent used for thinning, cleaning paint and varnish removal.

User-Centric

Designed with a primary focus on meeting the needs and preferences of users.

A: Appendix (to be changed)

Document ID

Document Statistics

Table 2. Document Stats

Number of words	2318
Average Word Length	5
Average number of words per sentence	15
Total Number of characters with spaces	17,983
Total Number of character without spaces	14,254
Total Number of Letter characters	11,719
Total Number of Sentences	141
Number of Unique Words	940

Number of Repeat Words	2087
Number of Syllables	3874

Readability Indices ? explain a bit about ranges

Table 3. Readability Stats

Readibility Index	Score	Difficulty
Flesch Reading Ease	63	Standard
Gunning Fog Readibility	11.3	Fairly Difficult
Coleman Liau Readibility Index	10.51	Fairly Difficult
Flesch Kincaid Grade Level	6.96	Average
Automated Readibility Index	11.01	Fairly Difficult