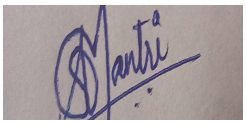
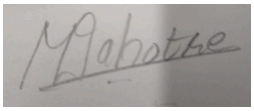
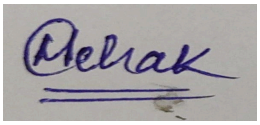
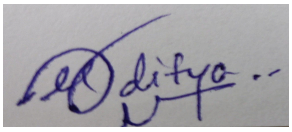
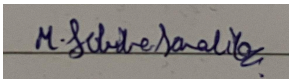
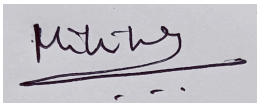
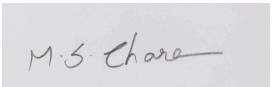
ES - 101

Mechanical Pendulum Clock

Free Hand Sketches

Prepared By: Group - 15

Summer Term - ES 101 - Engineering Graphics

Sr. No.	Team Member	Signature
1	Anura Mantri (22110144)	
2	Mohit Maurya (22110145)	
3	Mayank Gulati (22110146)	
4	Mayank Dahotre (22110147)	
5	Md. Sibtain (22110148)	
6	Mehakpreet (22110149)	
7	Aditya Mehta (22110150)	
8	Sonalika (22110151)	
9	Mihika Desai (22110152)	
10	Sai Charan (22110153)	

Complete Gear Mechanism and Working of Clock

(Since, the parts allotted to all of us are mostly gears and the working of every gear cannot differ greatly; so, we are defining the complete working of the clock and the gear mechanism together.)

We know that the hour hand moves 5/60 of complete rotation in 1 hour (60 minutes) and the minute hand moves 1/60 of complete rotation in 1 minute.

Now, according to the time period of the pendulum, as the pendulum does to and fro motion, the escapement also does the to and fro motion. Now, some weight is connected to the gear which is controlled by the escapement part.

All the modifications mentioned below were made by keeping in mind the gear ratio.

Gear 1, Gear 2 and Gear 3 mentioned in the below complete diagram are connected together. Now, Gear 4 is connected to Gear 3 with the help of axle rod in the perpendicular direction of the above gears and this is connected to the smaller gear, Gear 5. Gear 5 is connected to the bigger gear i.e. Gear 6 in another plane. This Gear 6 is connected to another smaller gear, Gear 7. Similarly this gear is connected to bigger gear, Gear 8 in another plane. Gear 8 is connected to another smaller gear, Gear 9 in similar process and then to the bigger gear, Gear 10. Gear 10 is the final gear connected to the escapement section which is completely dependent on the pendulum. Gear 1 leads the hour hand, Gear 10 directs the second hand and Gear 12 directs the minute hand. Gear 11 is connected with Gear 3 on the same rod.

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. Below table gives the data of the requirements of the time at every gear, number of teeth and pitch diameter.

Gear Number	Time taken per Rotation	Number of Teeth	Pitch Diameter (in mm)
1	720 minutes	80	203.2
2	360 minutes	40	101
3	90 minutes	10	25.4
4	90 minutes	60	152.4
5	15 minutes	10	25.4
6	15 minutes	60	152.4
7	3 minutes	12	30.4
8	3 minutes	30	76.2
9	1 minutes	10	25.4
10	1 minutes	30	76.4
11	90 minutes	60	258.12
12	60 minutes	40	172.08

Modifications from the Proposed Model

On deciding on a vintage metal theme for our clock, we had to change the outer appearance. The working mechanism in the proposal only included Hour and minute hands; however, to add an extra minute hand, we had to modify gears and other dimensions as well as add a few gears.

The gear mechanism decided in the proposal has to be changed completely since the principles of minute hand and hour hand in any ordinary clock were wrong. Gear Ratio, Number of Gears and Number of Teeth, all things were changed.

The new number of gears are 12 (distributed across 3 sub-parts, 3 used for hour hand, 2 for minute hand, and 7 for second hand.) and also the radius is changed in order to maintain the gear ratio. The ratchet and pawl part in the proposal have been removed. The length of the pendulum is to be increased to a proportion in order to keep the time period the same.

Although Pendulum and Escapement remain the same. Also, for the design purpose we changed the size of the dial and further we changed the size of the minute and hour hands also.

Dial: The dial is now circular in shape along with a photo-frame like border and designs for adding to the aesthetics of the clock. The numbers are embossed roman numerals. The dial is not a disc but a ring-like structure for ensuring the visibility of the inner gear mechanism.
Hands: The design of the hands was changed to match with the theme of the clock.
Frame: The frame is also changed from rectangular to circular. It is now transparent for making the gears visible.

All thoughts of the Modifications and correctness of the Working Model were made by:
Anura Mantri (22110144)
Mohit Maurya (22110145)
Aditya Mehta (22110150)

Front View of the Mechanical Clock

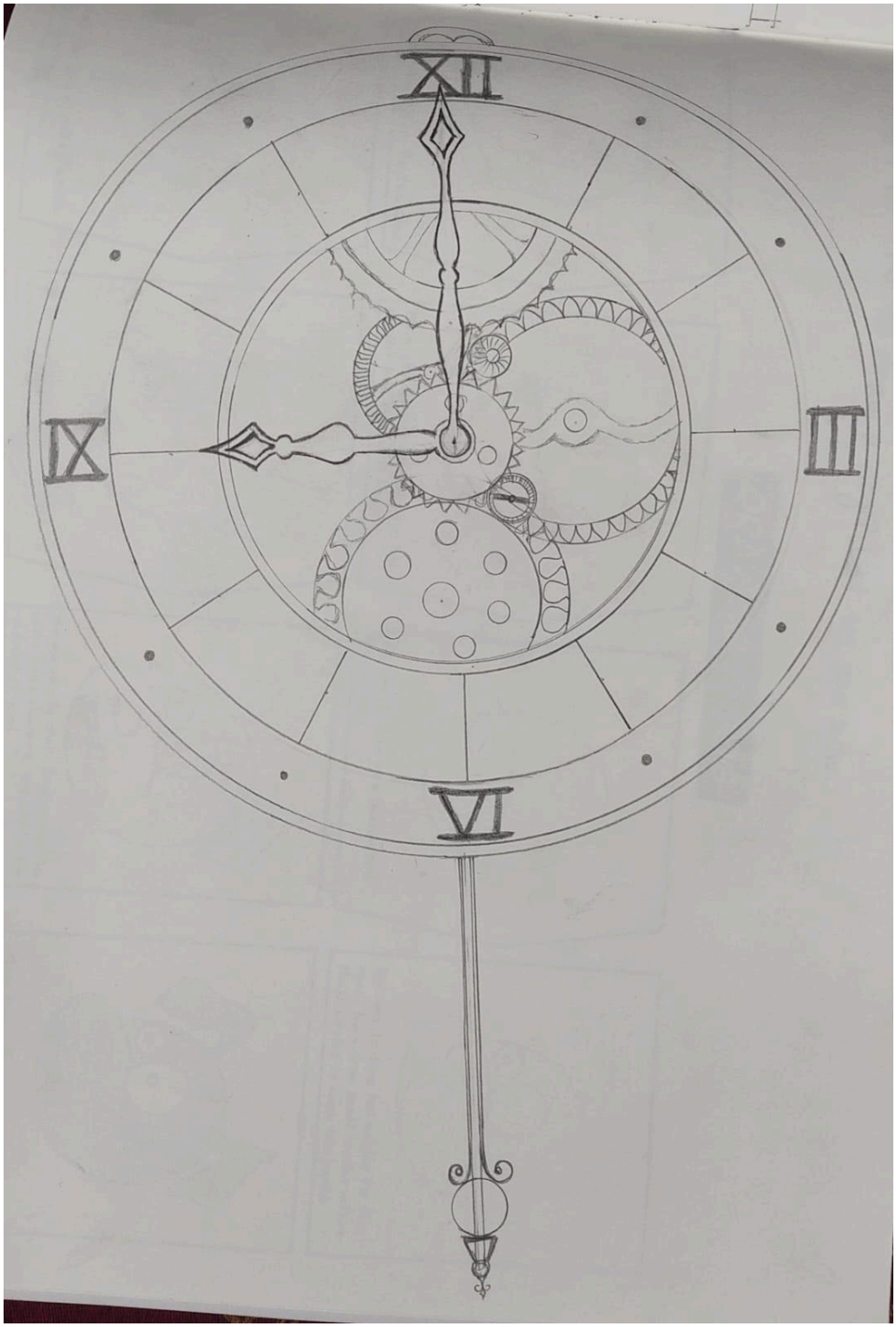


Fig 1. Front View of the Clock

Side View of the Mechanical Clock

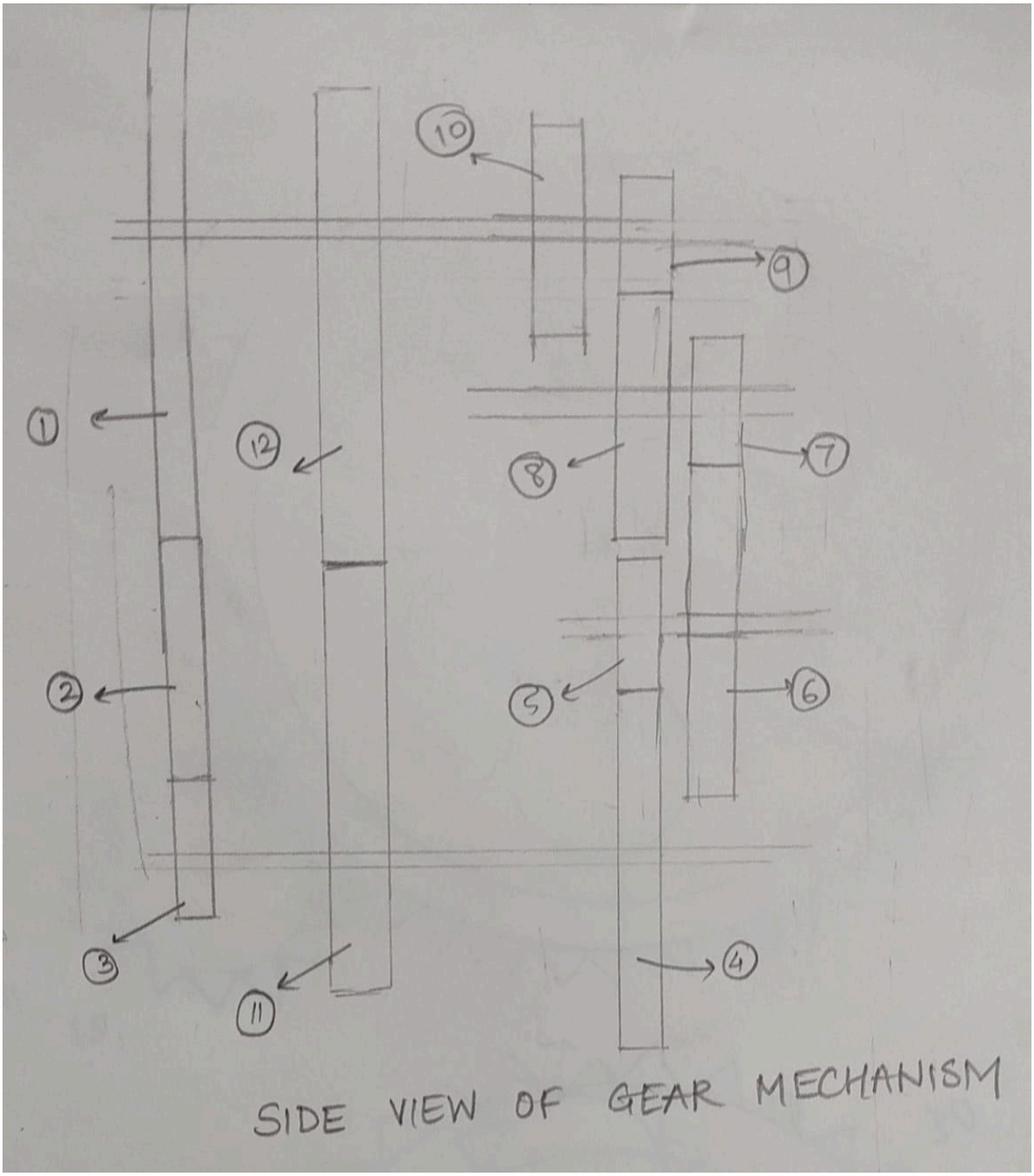


Fig 2. Gear mechanism

Free Hand Sketches and Dimensions

By Anura Mantri (22110144):

- Clock Face/ Dial
-

Sketches

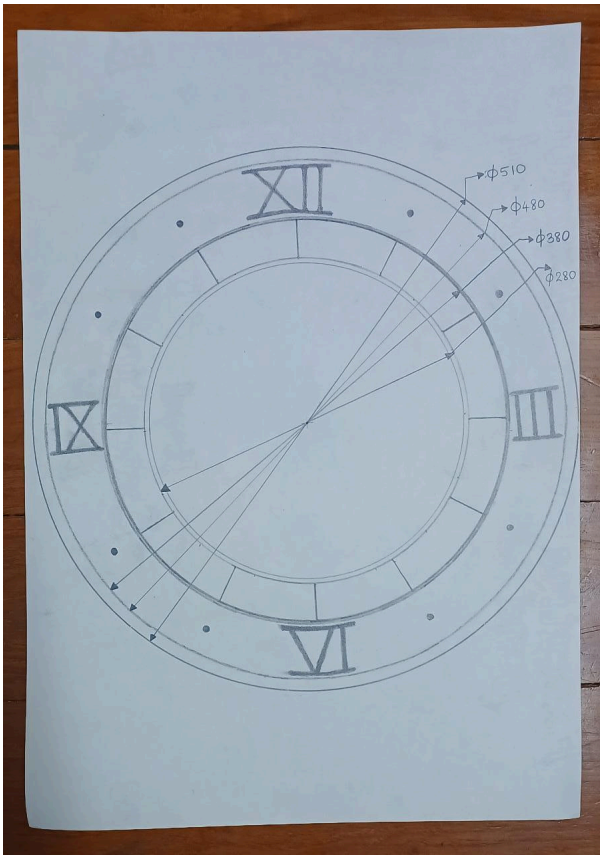


Fig 3. Clock dial

Materials of Parts

The materials used for making the dial are composite materials.These materials are made by combining different layers or particles with resins or adhesives, resulting in a durable and customizable surface.

Reasons of Selected Dimensions:

Dimensions of the Dial are:
Outer diameter: 510 mm
Frame diameter: 480 mm
Inner circle: 280 mm
The reason for choosing these dimensions is that the gear mechanism should be visible from the inner circle while also taking care of the hands not being overlapped with the gears. The hands should be clearly visible. The font size of the numbers should also be such that it can be seen from a distance. Thus these dimensions decide the actual size of the clock while supporting the complete structure.

By Mohit Maurya (22110145):

- Second, Minute and Hour Hand
- Gear 12

Sketches

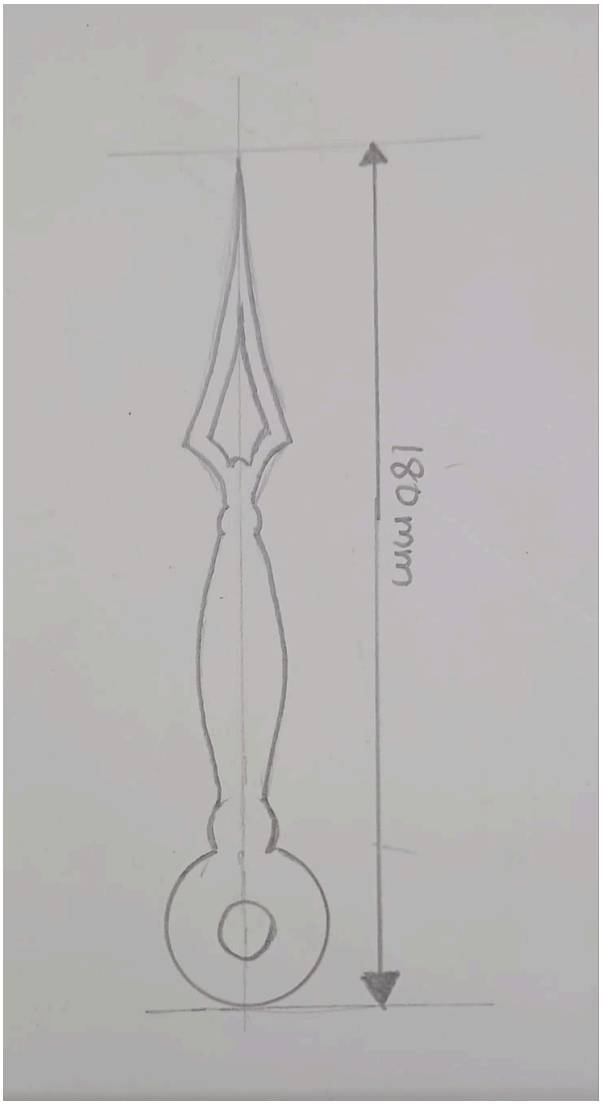


Fig 4. Second Hand

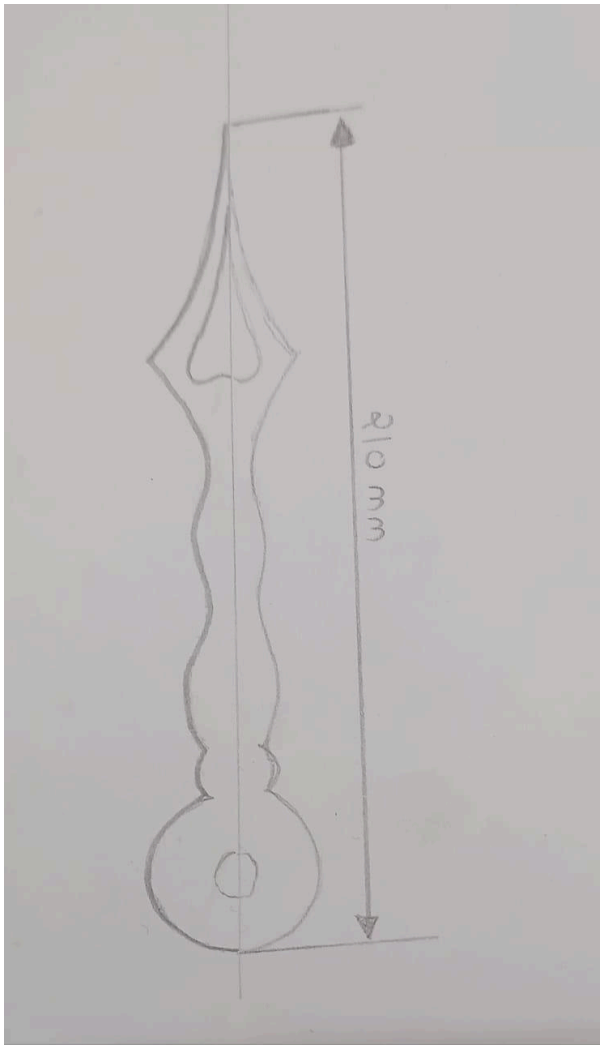


Fig 5. Minute Hand

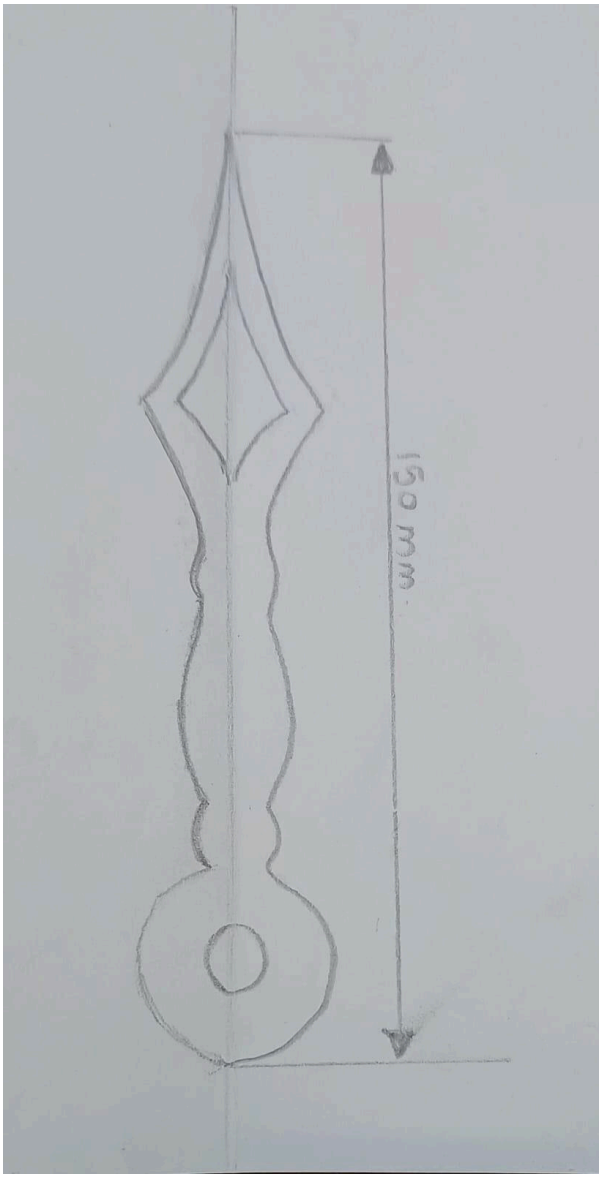


Fig 6. Hour Hand

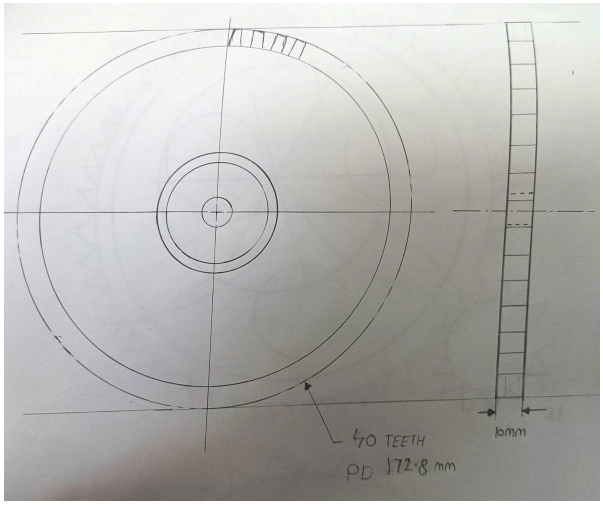


Fig 7. Gear 12

Reasons of Selected Dimensions:

The minute hand is the longest among the three, with a length of 210mm. This is followed by the second hand, which measures 180mm in length. Finally, the hour hand has a length of 150mm, as per traditional clock design standards. These sizes have been carefully chosen to ensure they are in proportion with the size of the clock's dial.
The shape of axial of is hollow cylinder which are coaxial in nature

Materials of Parts

To construct the hands and axial, I have opted for a composite material. The selection of this material is based on several factors. First and foremost, it possesses strength, ensuring that the hands can withstand the stresses and movements associated with clock mechanisms. Additionally, the composite material is lightweight, which is crucial for maintaining the smooth and accurate operation of the clock.

By Mayank Gulati (22110146):

- Intermediate Gears - Gear 1 and Gear 2

Sketches

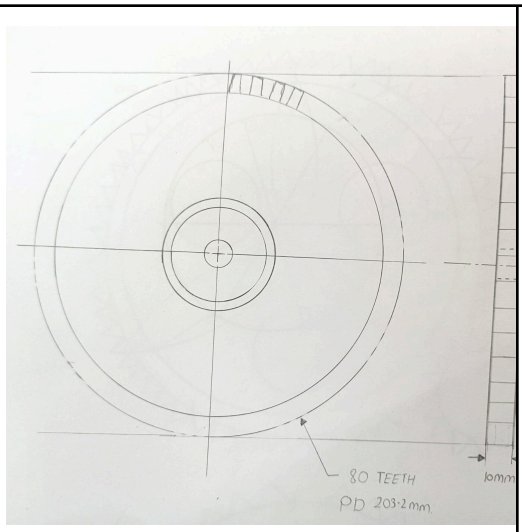


Fig 8. Gear 1

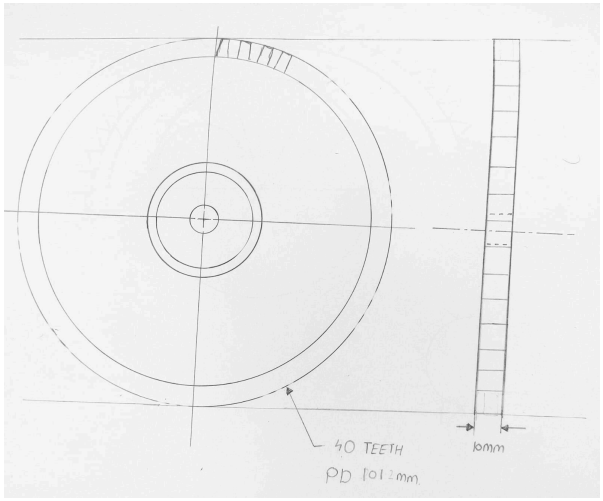


Fig 9. Gear 2

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:
Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used
Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

By Mayank Dahotre (22110147):

- Intermediate Gears - Gear 3 and Gear 4

Sketches

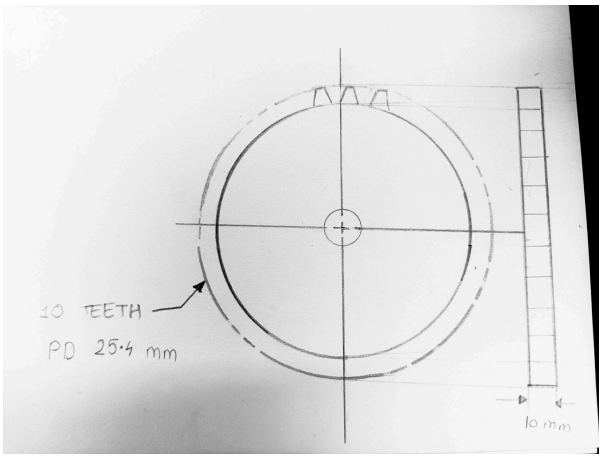


Fig 10. Gear 3

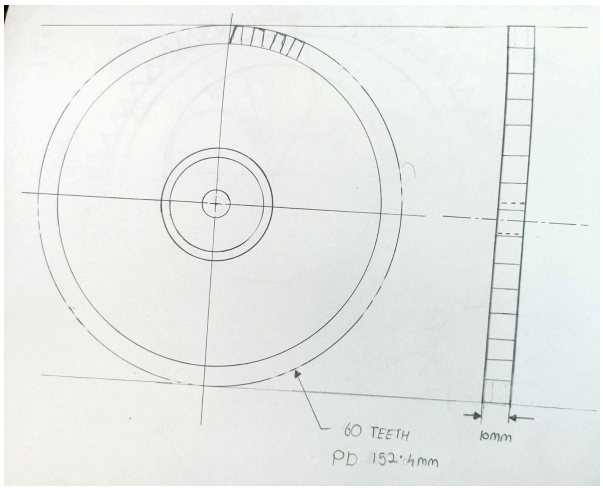


Fig 11. Gear 4

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:
Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used
Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

By Md Sibtain Raza (22110148):

- Pendulum
  - ❖ Pendulum Rod
  - ❖ Pendulum Bob
  - ❖ Pendulum Hanger
  - ❖ Pendulum Head
  - ❖ Pendulum Nut
  - ❖ Yoke

Sketches

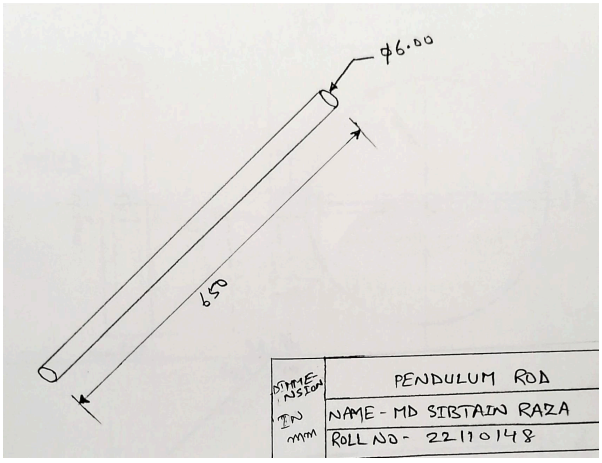


Fig 12. Pendulum Rod

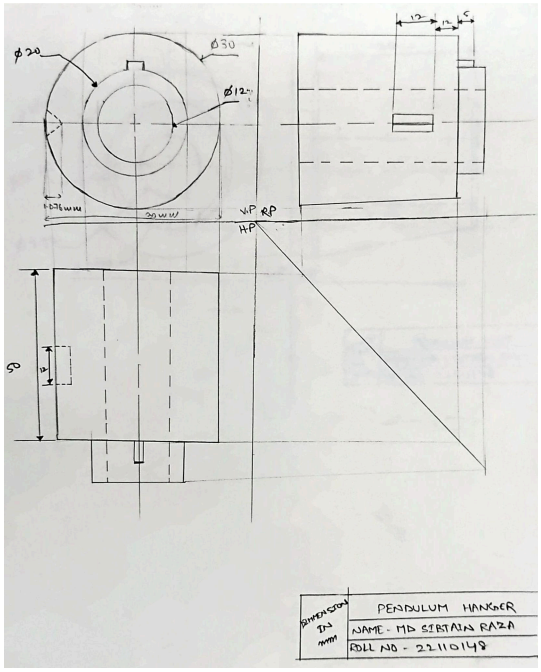


Fig 13. Pendulum Hanger

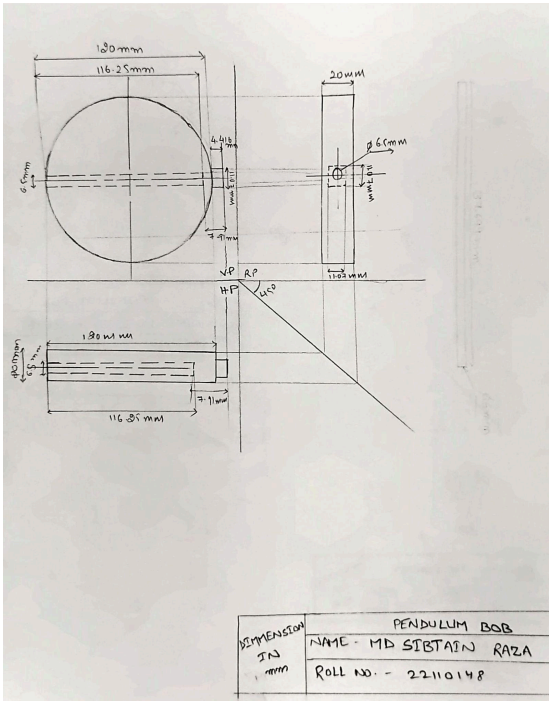


Fig 14. Pendulum Bob

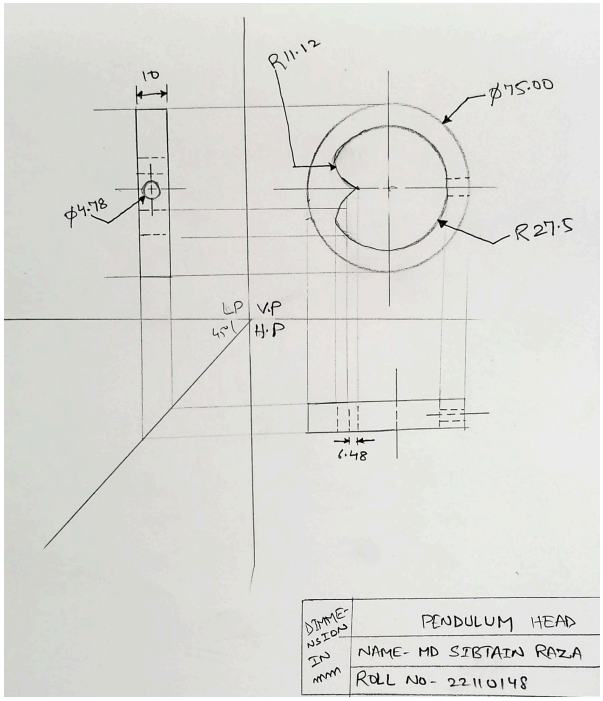


Fig 15. Pendulum Head

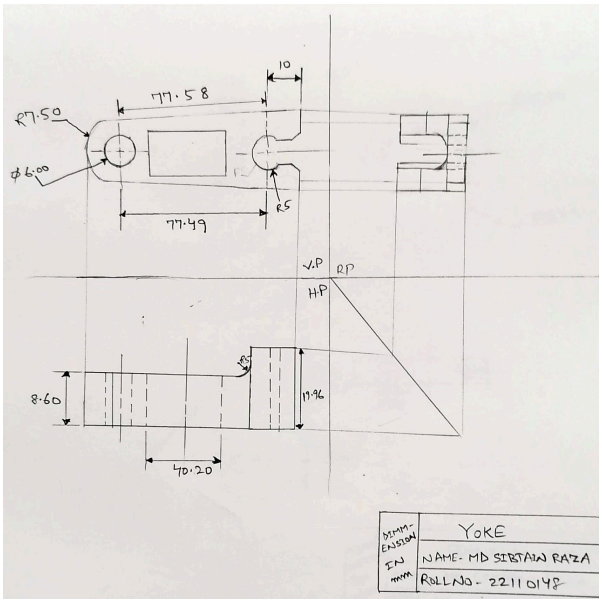


Fig 16. Yoke

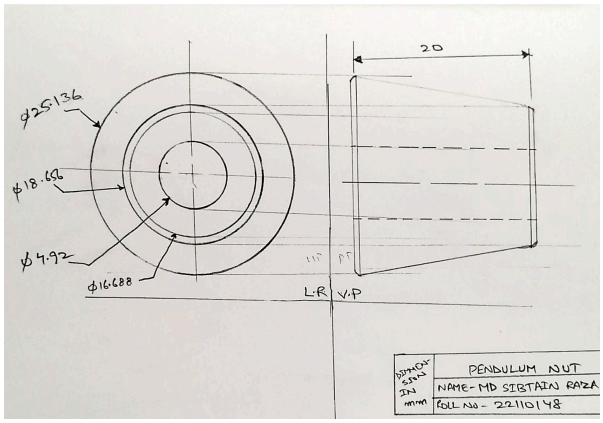


Fig 17. Pendulum Nut

Materials of Parts

The materials commonly used for the different parts of a pendulum are primarily metals such as brass, copper, steel, and lead. Brass and copper are often utilized for the pendulum bob due to their density, which provides the necessary weight for the pendulum's swinging motion. Steel is a popular choice for the pendulum rod because of its strength, durability, and low thermal expansion. The pivot point, where low friction is crucial, can be made of jewel bearings like synthetic sapphire or ruby. Additionally, the mounting bracket or frame can be crafted from metals like brass or steel, ensuring stability and support for the pendulum.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. The pendulum's dimensions selection is based on several factors, including the desired characteristics and behavior of the pendulum system, as well as practical considerations. Here are some common reasons for selecting specific dimensions for a pendulum:

- **Pendulum Rod:** The length of the pendulum affects the period of oscillation, which is the time it takes for the pendulum to complete one full swing. Longer pendulums generally have longer periods, while shorter pendulums have shorter periods.
- **Pendulum Bob:** The mass of the pendulum bob also influences its behavior. A heavier bob will have more inertia and swing more slowly, while a lighter bob will swing more quickly.
- **Angular amplitude:** The angular amplitude of the pendulum refers to the maximum angle it swings away from its equilibrium position.

It's important to note that selecting dimensions for a pendulum is often an iterative process, where initial dimensions are chosen based on theoretical considerations or previous experience and then adjusted through experimentation and analysis to achieve the desired behavior or performance.

By Mehakpreet (22110149):

- Intermediate Gears - Gear 5 and Gear 6

Reason for selecting dimensions:

Sketches

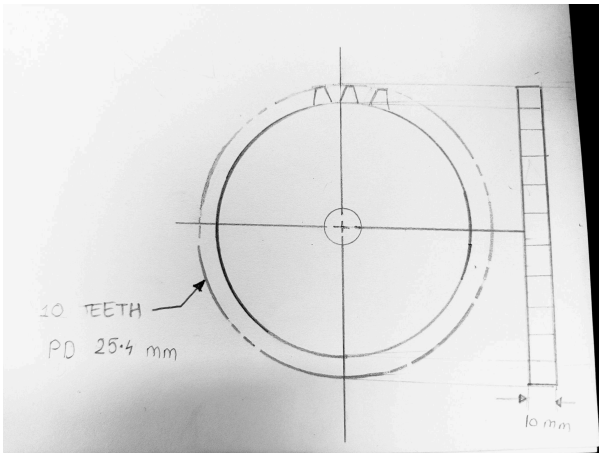


Fig 18. Gear 5

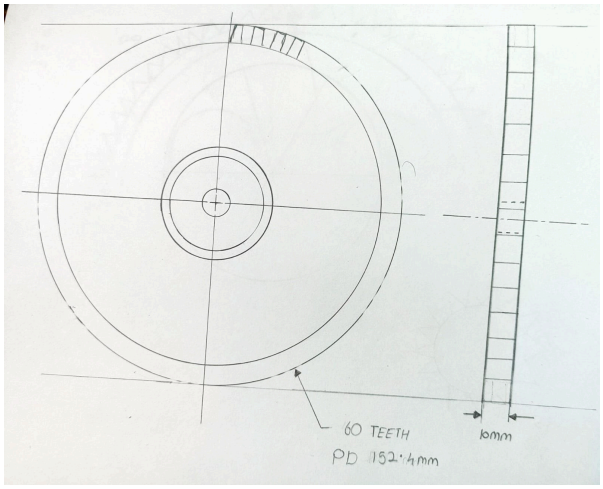


Fig 19. Gear 6

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:
Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used
Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

By Aditya Mehta (22110150):

- Escapement
- Gear - Connected with main gear of pendulum (Gear 10)
- Two spindles
- Drum

Sketches

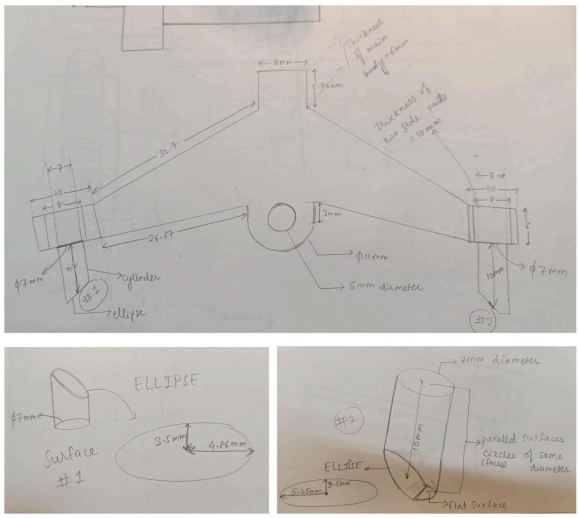


Fig 20. Escapement tool

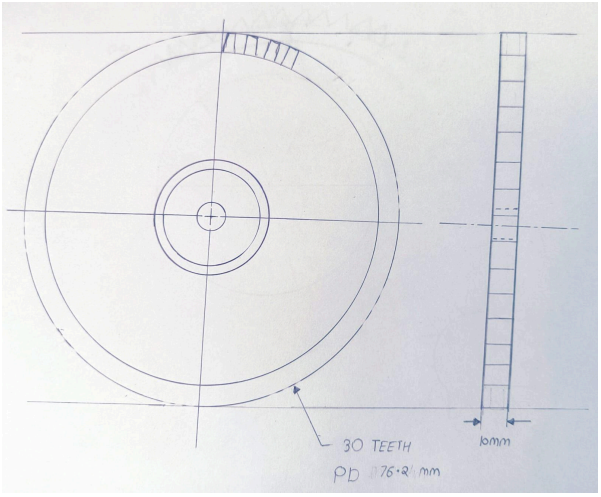


Fig 21. Gear 10 (Connected with Pendulum through Escapement)

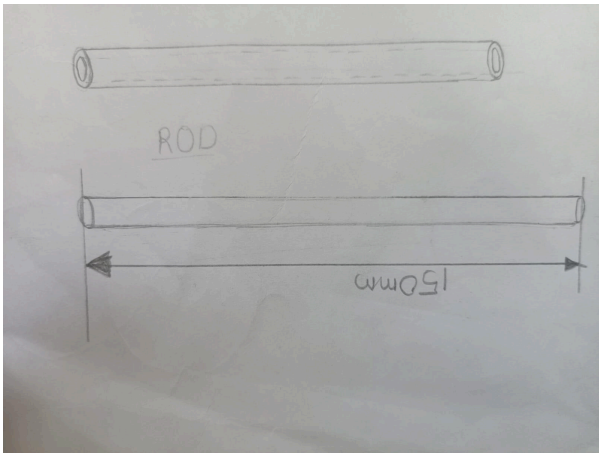


Fig 22. Spindles (Rods)

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:
Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used
Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

The escapement part will be made from metal similar to the old methods.

Reasons of Selected Dimensions

The dimensions of the Escapement part are in order to control that main gear.

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

Specific Modifications

There are no modifications in the Escapement part of this Clock. All the dimensions of this part remain the same. But, there are modifications in the gear. The dimensions and position of that gear has changed, although the number of teeth remains the same.

By Sonalika (22110151):

- Intermediate Gears - Gear 7 and 8

Sketches

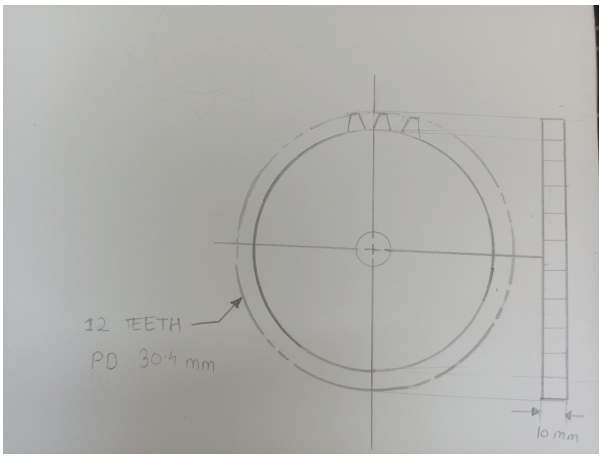


Fig 23. Gear 7

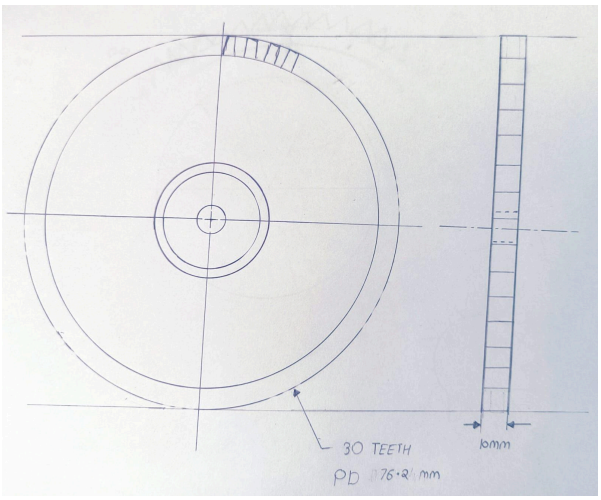


Fig 24. Gear 8

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:
Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used
Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

By Mihika Desai (22110152):

- Intermediate gears - Gear 9 and 11
- Drum

Sketches

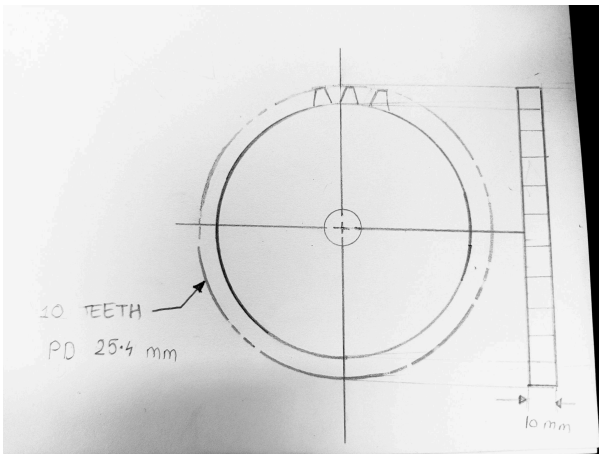


Fig 25. Gear 9

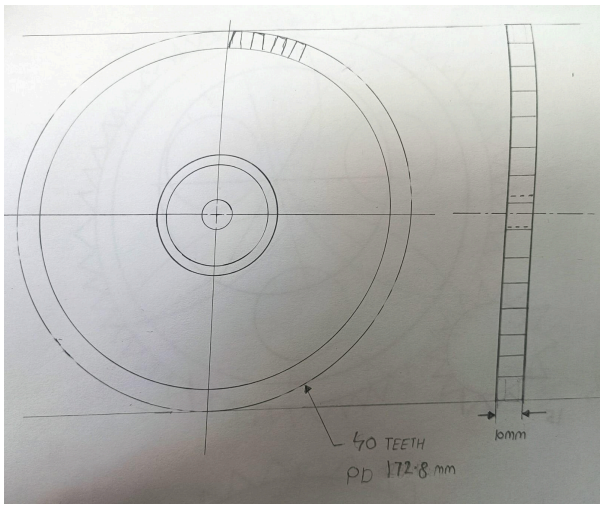


Fig 26. Gear 11

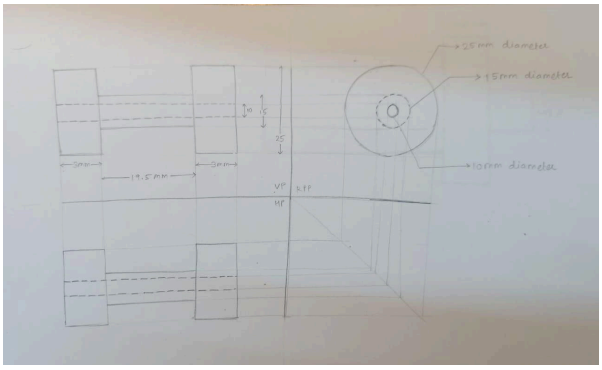


Fig 27. Drum

Materials of Parts

Gears can be made from a variety of materials based on the specific application requirements. Here are some commonly used materials for gears:

Steel: Steel has high strength, durability, and excellent wear resistance. Different types of steel, such as carbon steel, alloy steel, or stainless steel, can be used

Brass: Brass gears are frequently used in applications where low noise and smooth operation are desired, such as in clocks and small precision mechanisms. Brass offers good corrosion resistance and is relatively easy to machine.
Bronze: Bronze gears are known for their excellent wear resistance and ability to operate at high speeds. They are commonly used in applications where high strength and resistance to galling (metal-to-metal friction) are required. Bronze gears are often found in heavy machinery and automotive applications.

Reasons of Selected Dimensions

All the dimensions of the gear i.e. number of teeth and Pitch Diameter are decided on the basis of the time that has to be taken to complete one rotation and the number of teeth that should be rotation for the time we want. All the dimensions are mentioned in the above general table.

Drum: The drum is an essential component of the clock that holds the mainspring, which provides the power for the clock's mechanism. For the drum, a suitable material could be brass or steel. Brass offers good corrosion resistance, machinability, and an attractive appearance. Steel, on the other hand, provides excellent strength and durability. The choice between brass and steel depends on factors such as the clock's design, aesthetic preferences, and desired level of robustness.

By Sai Charan (22110153):

- Frames(x2)
- Rods between frames(x4)
- 5 Spindles

Sketches

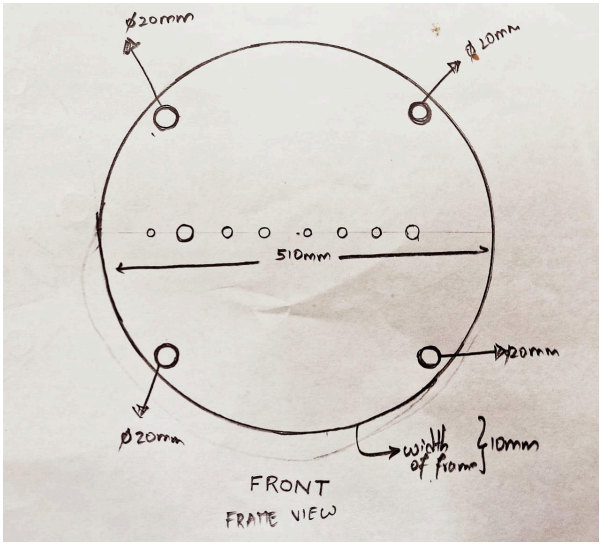


Fig 28. Frame - Front View

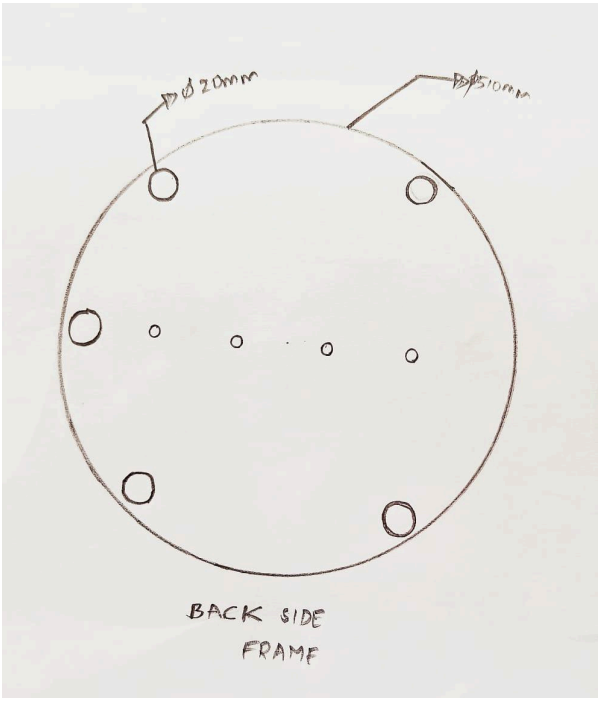


Fig 29. Frame - Back View

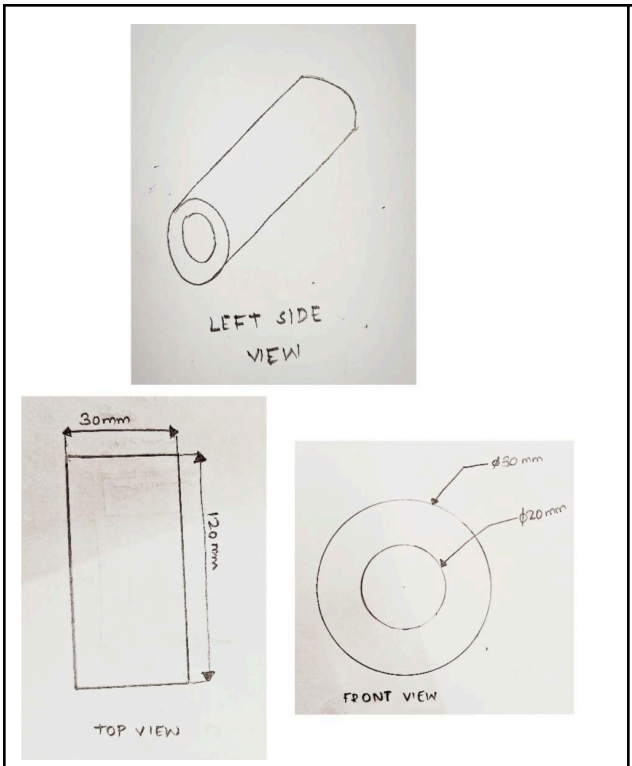


Fig 30. Rods between frames

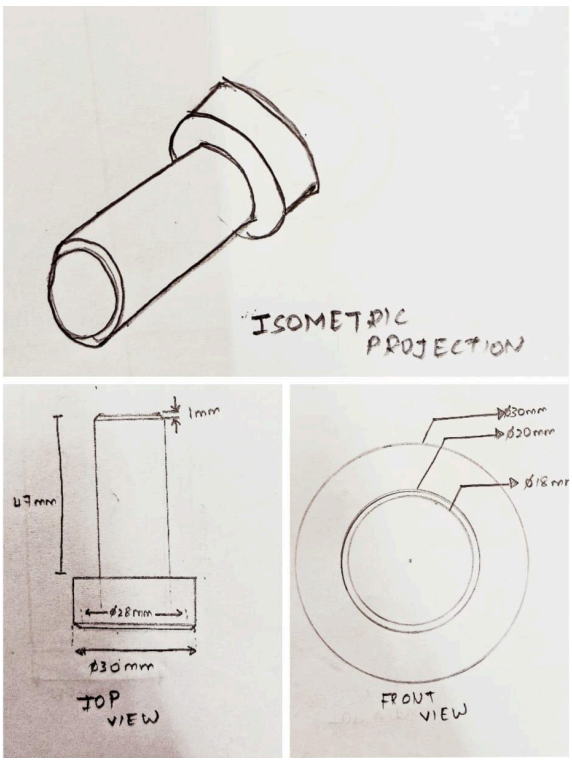


Fig 31. Rods between frames

Materials of Parts

As the frames made for the clock are supposed to be transparent, we may use acrylic to make these frames. We should especially use it as they are more durable and resistant to scratches.Another main reason of using acrylic as acrylic can be easily shaped, cut, and engraved to create intricate designs or patterns on the clock frames.

Reasons of Selected Dimensions

The diameter for the clock's frame is taken as 510mm and the frame is 10mm wide. The measurements of the clock's frames were dependent on the size of the clock and inner parts. All the internal parts of the clock are enclosed within those frames and the rods are given support using the frame. So the dimensions for frames of the clock are taken by considering the length of rods and the number of rods required. Moreover the selected diameter could give the clock a size and proportion that are aesthetically pleasing.