ES - 101

# Mechanical Pendulum Clock

## Project Proposal

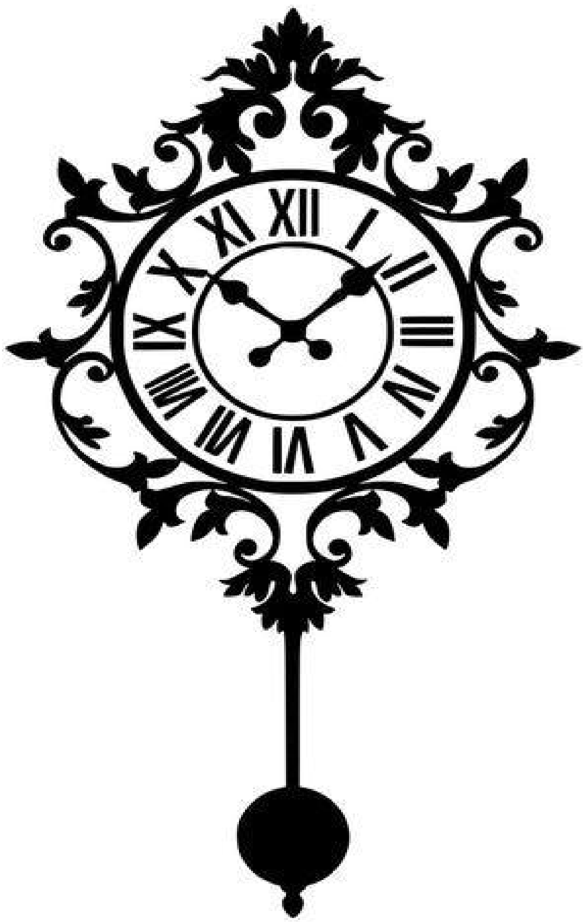



Fig 1.1, Mechanical Pendulum Clock

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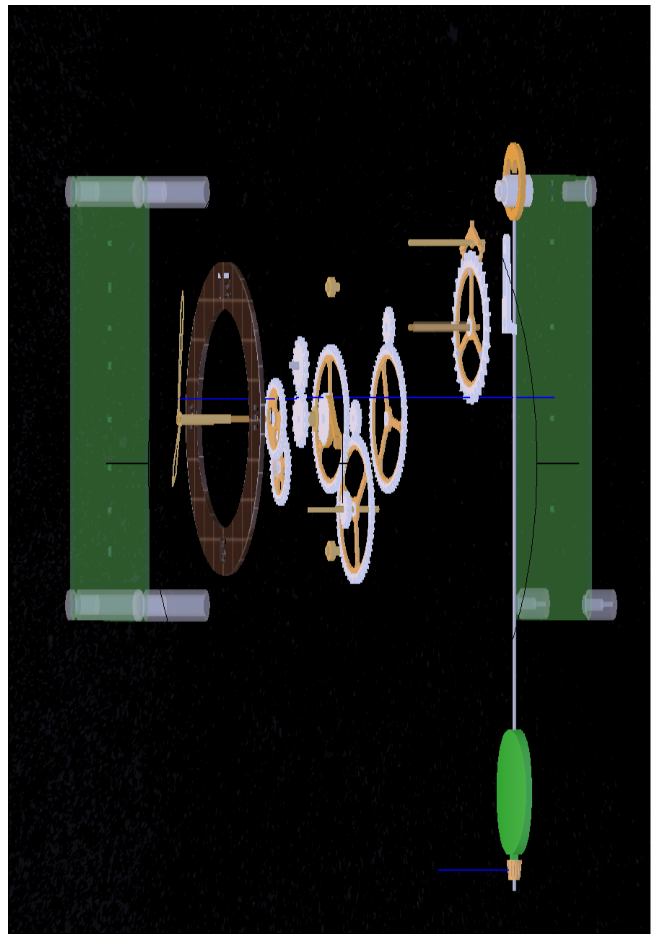

Fig 1.2, Exploded View of Proposed Clock

https://grabcad.com/library/mechanical-clock--1

Prepared By: Group 15

# Summer Term - ES 101 - Engineering Graphics
# Group 15

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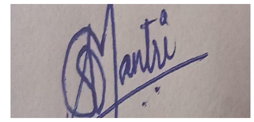
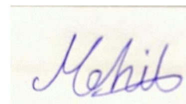
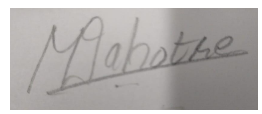
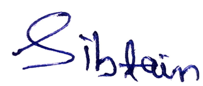
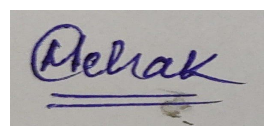
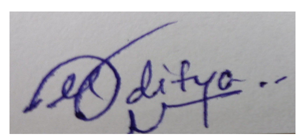
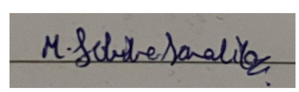
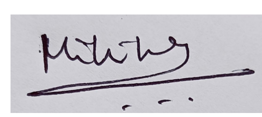
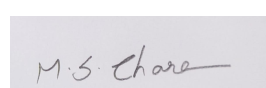
|---|---|---|
| 1 | Anura Mantri (22110144) |  |
| 2 | Mohit Maurya (22110145) |  |
| 3 | Mayank Gulati (22110146) |  |
| 4 | Mayank Dahotre (22110147) |  |
| 5 | Md. Sibtain (22110148) |  |
| 6 | Mehakpreet (22110149) |  |
| 7 | Aditya Mehta (22110150) |  |
| 8 | Sonalika (22110151) |  |
| 9 | Mihika Desai (22110152) |  |
| 10 | Sai Charan (22110153) |  |

# Introduction and Motivation

**Aditya Mehta (22110150)**
**Mayank Gulati (22110146)**

As the saying goes, “You can’t turn back the clock. but you can wind it up again”. So, by understanding the importance of clock and time, our group got motivated to work on modeling a Mechanical Pendulum Clock.

From its invention in 1656 (25th December) by Christiaan Huygens and patented the following year, inspired by Galileo Galilei, until the 1930s, the pendulum clock was the world's most precise timekeeper, accounting for its widespread use. He described it in his manuscript Horologium published in 1658. Huygens contracted the construction of his clock designs to clockmaker Salomon Coster, who actually built the clock. Galileo discovered the key property that makes pendulums useful timekeepers: isochronism, which means that the period of swing of a pendulum is approximately the same for different sized swings. The advantage of a pendulum for timekeeping is that it is an approximate harmonic oscillator. It swings back and forth in a precise time interval dependent on its length, and resists swinging at other rates.

The motivation behind selecting a mechanical clock with a pendulum as our project stems from our fascination with the artistry, precision engineering, and timeless elegance associated with antique timepieces. By choosing to create a working mechanical clock, we aim to delve into the captivating world of horology, engineering prowess, and aesthetic design.

Clocks and watches are mainly composed of the prime mover system, transmission system, escapement governor, pointer system and winding needle system. The mechanical clock uses a clockwork as the motive force of the driving system, and drives the escapement governor to work through a transmission system composed of a set of gears, and the escapement governor in turn controls the speed of the transmission system. The drive train drives the pointer mechanism while pushing the escapement governor. The speed of the drivetrain is controlled by the escapement governor, so the pointer can indicate the time on the dial according to a certain rule. The winding needle is a mechanism to wind up the mainspring or move the pointer.

Mechanical clocks use a pendulum as their oscillator, which controls the rotation of a system of gears that drive the clock display. It depends on a mechanism called an escapement that moves back and forth in a steady rhythm. Most escapements were masses on the ends of a crossbar that rhythmically rotated back and forth on a shaft.

When a pendulum is displaced sideways from its resting, equilibrium position, it is subject to a restoring force due to gravity that will accelerate it back toward the equilibrium position. Each swing of the pendulum a pallet releases a tooth of the escape wheel. The wheel rotates forward a fixed amount until a tooth catches on the other pallet. These releases allow the clock's wheel train to advance a fixed amount with each swing, moving the hands forward at a constant rate, controlled by the pendulum.

We aim to immerse ourselves with Autodesk Inventor to create visually captivating 3D models. Through this project, we will not only enhance not only design skills but also gain a profound understanding of the innovation and craftsmanship that have shaped the evolution of mechanical clocks throughout history.

Moreover, this project offers us the chance to engage in collaborative teamwork and project management, which are crucial skills in the field of engineering. We shall divide all the parts among ourselves, and all of us will explore new functions of the Autodesk Inventor software and make our mechanical clock worth the effort. We shall try to do our best in the assembly.

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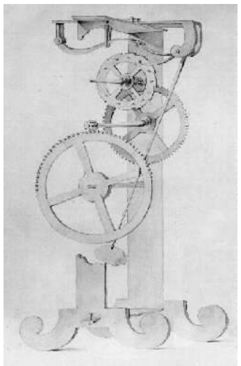
|  |  |
| Fig 2, Pendulum Clock by Galileo Galilei | Fig 3, Wooden Mechanical Clock |

# References


1. https://en.wikipedia.org/wiki/Pendulum_clock
2. https://grabcad.com/library/mechanical-clock--1
3. https://www.linkedin.com/pulse/whats-structure-working-principle-mechanical-clocks-sarah-lee?trk=portfolio_article-card_title

# Detailing of following parts done by Anura Mantri (22110144):

- Clock Face/ Dial

## Introduction

The component of a mechanical clock that displays the time and makes it easier to determine the time is called a clock dial, also known as a clock face. It usually takes the form of a circular plate made of metal, glass, or another material that has markings or segments to represent the hours, minutes, and occasionally seconds. The clock's face, as its name implies, determines the object's general appearance and aesthetic appeal. The dial is enclosed in a sturdy framework with attractive decorative motifs that provide a sense of sophistication to the timekeeping device. Precision timekeeping is made possible by the minute track, the outermost ring, which has 60 equally spaced divisions for each minute.These divisions are identified by elongated, slender indices. The hour track, which represents the flow of hours throughout the day, is followed as you move inward. It typically has 12 Roman numerals that are elegantly spaced out throughout the 360° and placed at regular intervals. The color and size of these markings should be carefully considered, and they should be large enough to be seen from a reasonable distance. When choosing the radius of the dial, it's crucial to keep the length of the clock's hands in mind. The clock display captures the essence of time and transforms into a compelling centerpiece, enriching any room it occupies with its harmonious combination of precision, artistry, and aesthetics.

## Modeling

I will begin modeling on Autodesk Inventor with a simple circular frame on a plane using the 'circle' function.I will design one or more out of the 12 divisions depending on the symmetry and design of my clock face using different kinds of 'lines' offered on the software. If the design demands, I will have to work in layers to create a 3 dimensional illusion. I will have to take into account the hands of the clock and also the visibility of the numbers I choose for the display. After I am done with designing my parts, I will use the circular symmetry function for adding the designs on the circular frame in a way it appeals to the observer. I will extrude them as required. I will add the numbers or roman numerals on the circle using the inbuilt functions. It is important to make sure that it does not become too bulky or heavy for the frame to hold. I also have to add holes to the dial to fit the face on the frame and secure it with locking mechanisms. The dial could either be a ring or a circular plate. I will have to be vigilant while aligning the center of the dial with that of the frame. I will use appearances and materials tools to add suitable materials and texture to different parts of the clock dial. After completing the modeling process, I will review the design from all angles to ensure accuracy and symmetry and make changes if necessary.

## Potential Challenges

Hole Alignment: Creating the center hole for the clock mechanism requires careful alignment with the dial's center. Misalignment can cause the clock mechanism to be off-center or not fit correctly. I should pay attention to the position and dimensions of the center hole during sketching and extrusion. I have to be mindful of the size and scale of the surface details to ensure they look appropriate on the dial.
Material Application: Applying materials and textures to the clock dial is crucial for achieving a realistic look. However, selecting suitable materials and adjusting their properties (e.g., reflectivity, roughness) can be subjective and require some trial and error to achieve the desired result.
Symmetry and Accuracy Review: It is important to thoroughly review the clock dial design from various angles to ensure symmetry, accuracy, and a visually pleasing appearance. I must check for any inconsistencies, uneven surfaces, or unintended distortions.
Sketching Accuracy: When sketching the dial, it's essential to ensure precise dimensions, proportions, and alignment. Inaccurate sketches may lead to distorted or disproportionate dials.

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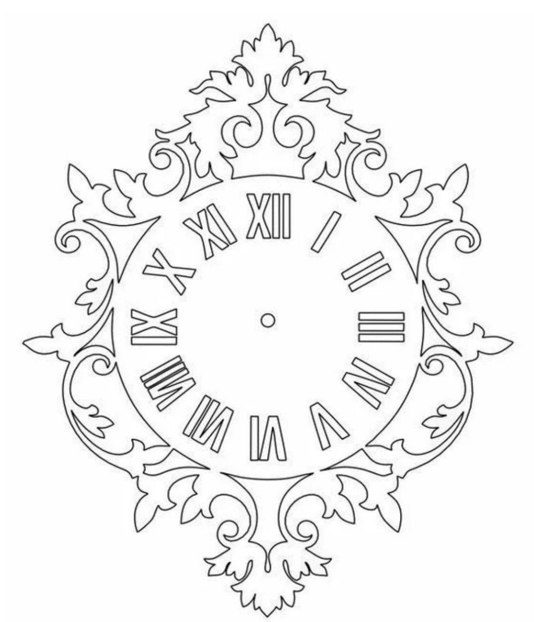
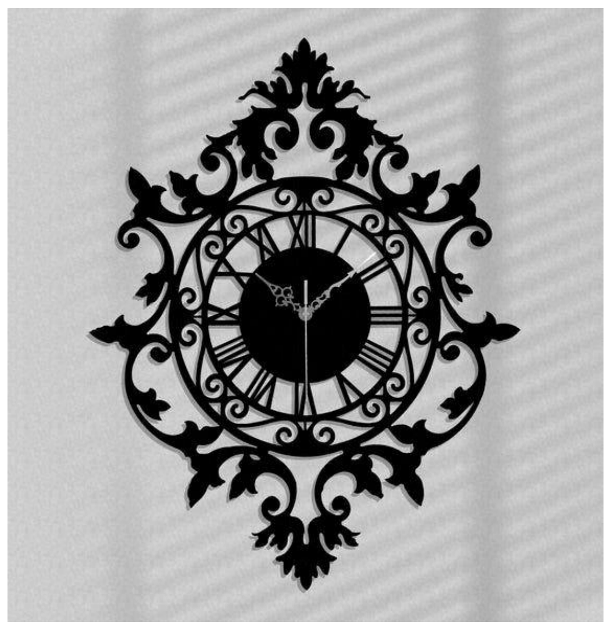
|  |  |
| Fig 4, Sketch for Proposed Dial | Fig 5, Final Look of Proposed Dial |

## References


1. https://en.wikipedia.org/wiki/Clock_face
2. https://in.pinterest.com/pin/615304367862620773/
3. https://in.pinterest.com/pin/615304367862620488/

# Detailing of following parts done by Mohit Maurya (22110145):

- Hour and Minute Hand
- Spindle

## Introduction

For the Engineering group project we have decided to make a mechanical pendulum clock. In a traditional pendulum clock, the hour hand and minute hand are distinct metal rods or needles that extend from the clock's center, usually positioned above the clock face.As the pendulum swings back and forth, it transfers energy to a set of gears, which in turn drive the motion of the hour and minute hands. The gears convert the back-and-forth motion of the pendulum into the rotary motion required for the hands to move around the clock face.The concept of using hands to indicate time on a clock face has a long history dating back centuries. The introduction of mechanical clocks in medieval Europe brought about the development of various timekeeping mechanisms, including the use of hour and minute hands. The earliest mechanical clocks, such as the verge and foliot clocks in the 14th century, used only an hour hand. These clocks were not highly accurate and primarily served to indicate the approximate hour of the day.

## Modeling

To make hour hand and minute hand, I will use Autodesk Inventor line option to make hand also to make a different design we can use arcs or different circles which can add to the aesthetics of the Hour and minute hand. Then I can extrude it to the appropriate length to convert the 2d sketch into a 3d model. Also, I have to make two spindles to connect the hour hand and minute hand to their respective gears. The spindles are just simple hollow cylinders which are coaxial.

## Potential Challenges

First problem we can face is in the assembly of these parts as these will require precision. Another problem which we can face is to add proper aesthetics to the hour and minutes hand which requires experience of working with Autodesk Inventor software.

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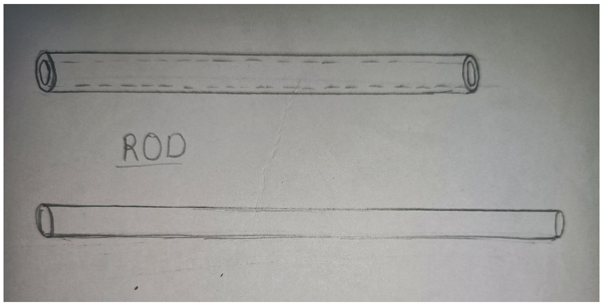
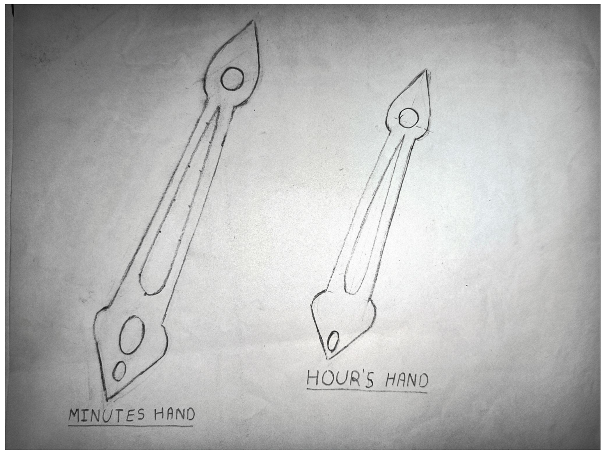
|  |  |
| Fig 6, Rod to connect the Hour and Minutes Hand | Fig 7, Design of hour and minutes hand |

## References

1)https://en.wikipedia.org/wiki/Gear
2)https://grabcad.com/library/mechanical-clock--1

# Detailing of following parts done by Mayank Gulati (22110146):

- Intermediate Gears

## Introduction

Our project revolves around a pendulum mechanical clock, which is an exquisite piece of craftsmanship, developed by humans in the 17th century. I will be working on two intermediate gears, which connect important parts of the clock, and so are an essential part of the whole mechanism.

## Uses

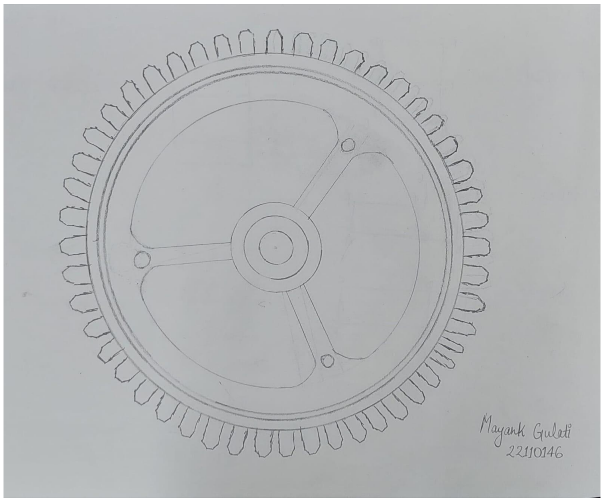
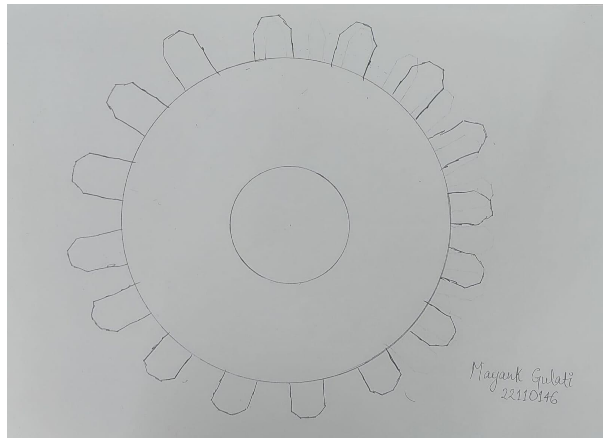
Gears play a crucial role in the operation of a mechanical clock with a pendulum. They are used to transfer and regulate the motion of the clock's mainspring or weights to the various components of the clock, including the pendulum, hands, and escapement mechanism.
The gears in a mechanical clock with a pendulum work together to transfer power, regulate the movement of the hands, and provide a constant and regulated energy supply to the timekeeping mechanism. The precise gear ratios and interactions ensure accurate timekeeping and the smooth operation of the clock.

## Modeling

To model a gear in Autodesk Inventor, start with a new part file. Create a new 2D sketch and create the outer circle of the gear. Using the spline tool, or the circular pattern tool (depending on the design of teeth of the gear), sketch the teeth of the gear. Use another circle to sketch the inner boundary of the gear. Leave a gap in the middle for any mount or bearing to be attached. Use the necessary tools to complete the design of the gear, and finish the sketch once it is ready to extrude. Then, extrude the gear as per the required thickness. Add any necessary filets or chamfers using the tools available in the 3D modeling workspace.

## Potential Challenges

1. **Complex gear profiles**: Certain gear types, such as involute gears with custom profiles, may require precise mathematical calculations and accurate modeling techniques. Creating complex gear profiles manually can be challenging and time-consuming. To overcome this challenge, you may need to rely on specialized add-ins or external tools to generate the gear profiles accurately.
2. **Meshing and interference issues**: Gears need to mesh properly with other components in a mechanism to ensure smooth operation. One common challenge is achieving correct gear meshing without any interference or collisions. If the gear teeth do not align properly or there are interferences with other components, the gear may not function correctly. In such cases, you may need to adjust the gear parameters, such as tooth size, module, or profile shift, to ensure proper meshing and resolve any interference issues.

|  |  |
|---|---|
| Fig 8, Gear | Fig 9, Gear |

# Detailing of following parts done by Mayank Dahotre (22110147):

- Intermediate Gears

## Introduction

Gears are essential for mechanical clocks, ensuring accurate timekeeping and enabling various functions. They form an interconnected system that converts energy into precise movement. The escape wheel converts constant force into intermittent motion and creates the ticking sound. The minute wheel governs the minute hand's movement, regulating the hour hand through the hour wheel. Additional gears enable complications like striking, chiming, and calendar indications. The precise design and craftsmanship of these gears reflect the artistry and engineering behind mechanical clocks, bringing time to life with charm and accuracy.

## Modeling

Some functions like chamfers or fillets to the edges of the gear teeth for smoother operation may be used. Apply appropriate materials and appearances to the gear to make it look realistic, using the "Material" and "Appearance" tools.

## Potential Challenges

Design Errors: Mistakes in the gear tooth profile or incorrect dimensions can lead to functional issues with the gears, such as improper meshing or slipping. It's important to double-check the design and ensure accurate measurements.
Interference: During the assembly of the gears and other components, there may be instances where parts interfere with each other, causing collisions or preventing proper movement. Careful attention should be given to the placement and alignment of the gears to avoid interference.
Assembly Constraints: Setting up the proper mates or constraints between the gears and other components can be challenging. Inadequate or incorrect constraints can result in unrealistic or incorrect movement of the gears. Understanding the assembly environment and utilizing appropriate constraints is crucial.

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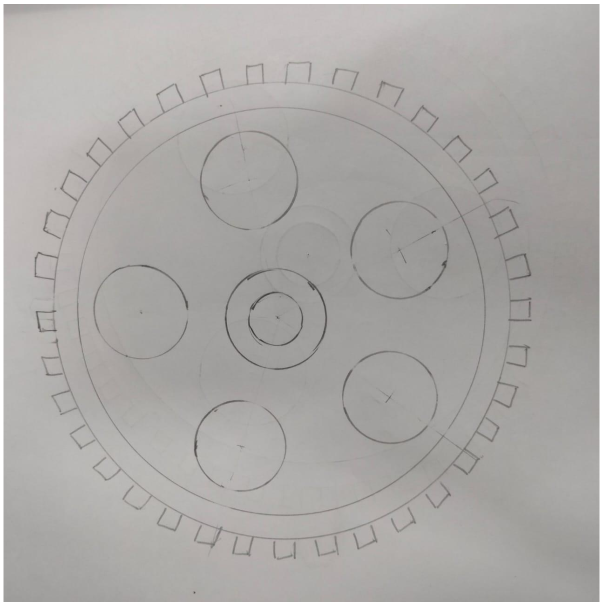
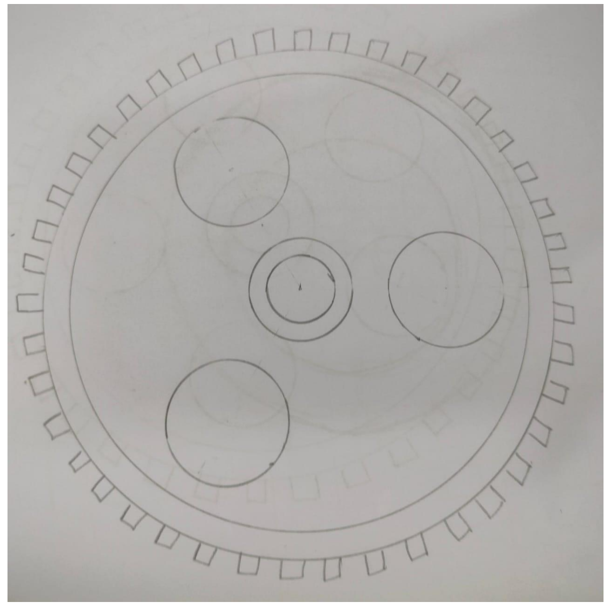
|  |  |
| Fig 10, Gear | Fig 11, Gear |

## References

https://grabcad.com/library/mechanical-clock--1

# Detailing of following parts done by Md Sibtain Raza (22110148):

- Pendulum

## Introduction

Combining craftsmanship and engineering, this project aims to bring the beauty and precision of traditional timekeeping to life. I have been assigned the task of designing and constructing the pendulum. The pendulum is a crucial component of a mechanical clock, serving as the regulating element that ensures accurate timekeeping. It consists of a weighted arm suspended from a fixed point, which swings back and forth consistently. The pendulum's length determines the clock's timekeeping precision, as it controls the frequency at which the clock ticks.

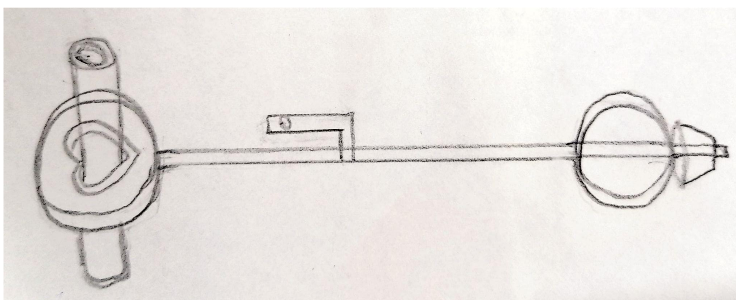


Fig 12, Pendulum

## Uses of the Pendulum in Mechanical Clocks

The pendulum plays a vital role in the functioning of mechanical clocks by providing a steady and reliable oscillating motion. Its primary purpose is to regulate the movement of the clock's gears, ensuring that the clock keeps time accurately. As the pendulum swings, it transfers energy to the clock's escapement mechanism, which controls the release of power from the clock's mainspring or weights. This energy transfer allows the clock to advance regularly and maintain precise timekeeping.

## Potential Challenges

Designing the pendulum for a mechanical clock using Autodesk Inventor can present several challenges. Here are some common difficulties that may arise during the design process:

1. Accurate Modeling**:** Accurate representation of the pendulum's geometry and dimensions is crucial for proper functioning. Ensuring precise measurements and dimensions, proper alignment, attachment points, and interaction with other

components within the software are challenging, as minor errors in design may lead to inaccuracies in the clock's timekeeping.

2. Integration with Clock Mechanism: Coordinating the pendulum design with the rest of the clock's mechanism can be intricate. Autodesk Inventor's assembly tools can aid in visualizing and verifying the integration of the pendulum within the clock's overall structure.

In conclusion, designing the pendulum for a mechanical clock requires attention to detail, accurate modeling, and careful consideration of various factors affecting its performance. Overcoming challenges related to accurate modeling, motion simulation, balancing, and integration will definitely lead us to success.

# Detailing of following parts done by Mehakpreet (22110149):

- Central Wheel
- Connector Wheel
- Rod

## Introduction

Our group is working on modeling a working mechanical clock which has a pendulum. This was the oldest human invention, but as technology improved it became an essential part of our daily lives. Now it includes many features like temperature, day, date, time etc.
Our model has about 50 parts (including screws and nuts), of which I have been assigned the work of modeling three parts, namely the working gear function of the clock. It plays a critical role in the functioning of the clock to make connections between the pendulum and the hands of the clock.

The exact timekeeping mechanism of the mechanical clock depends on gears, which are vital parts of the clock. A toothed wheel known as a gear transmits rotational motion or torque by meshing with other gears. Mechanical clocks can precisely measure and display the passage of time by utilizing gears of various sizes and configurations.

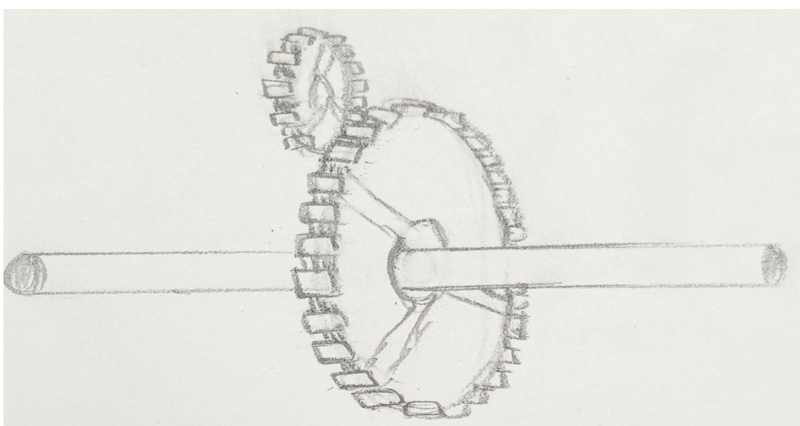


Fig 13, Central Wheel System

## Uses

The central gear in the clock's gear train is the center wheel. It delivers the escape wheel's rotational energy to the hour, minute, and second wheels after receiving it from the escape wheel. The gear ratios are based on the number of teeth on the center wheel, which also has an impact on the precision of the clock's timekeeping.
The connector gear is an essential component of mechanical clocks that connects the pendulum to the face of the clock, permitting the synchronization of timekeeping and the visible

representation of time. The pendulum's oscillatory motion is transmitted in a substantial way via the connecting gear to the clock's hands or other display devices.
The escape wheel or similar intermediate gear is often connected to the connection gear, which is typically located at the rear of the clock mechanism. The escape wheel's motion is transferred via the connection gear to the gear train that drives the clock's hour, minute, and second hands as the pendulum swings back and forth.

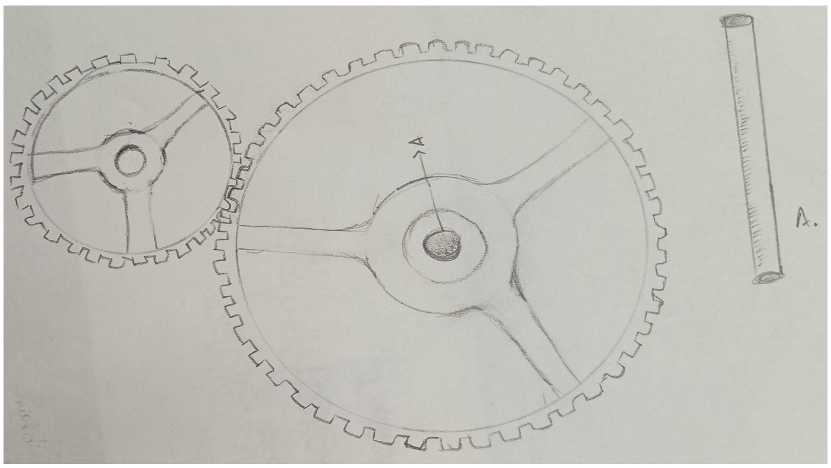



Fig 14, Exploded View of parts connected with Central Wheel

## Modeling

We can start by drawing the gear sketch in Autodesk Inventor while taking into account variables like the number of teeth and pitch diameter. Extrude the profile into a solid, smoothen it with filets and chamfers, and, if necessary, integrate mounting elements. Utilize the pattern command to duplicate gears. Verify whether any other components are interfering. Perform a finite element analysis to evaluate the structural quality. Create precise drawings for documentation, add annotations and dimensions, and complete the design. The design should be saved and exported in the proper format.

## Potential Challenges

Gears include complicated tooth profiles, involute curves, and different tooth sizes to guarantee seamless meshing and the best possible power transfer. In a solid modeling environment, the challenge is to faithfully depict these intricate geometries while taking into consideration the exact tooth shapes, root filets, and profile changes necessary for the gear's particular use.
Constraints on Interlocking and Meshing: To reduce backlash and guarantee smooth rotation, gears in a clock mechanism must be carefully built to mesh with one another. The challenge is to precisely define the contact sites, tooth profiles, and alignment characteristics in the solid model while including the interlocking and meshing limitations to ensure appropriate gear engagement and motion transmission.
Performance and Efficiency Optimisation: The challenge is to investigate design changes and enhancements to improve the performance and efficiency of the clock gears. This entails minimizing energy losses, minimizing friction, enhancing precision, and eliminating any issues with noise and vibration during gear operation.

## References


1. https://grabcad.com/library/mechanical-clock--1

# Detailing of following parts done by Aditya Mehta (22110150):

- Escapement
- Gear - Connected with main gear of pendulum
- Two spindles

## Introduction

As a saying goes, “Don’t watch the clock, Do what it does' '. Getting motivated by this, our group is working on modeling a Mechanical Pendulum Clock. I am working on the parts called Escapement, Gears which are connected to the main gear of the pendulum and two simple spindles. Escapement is the device that permits controlled motion, usually in steps.

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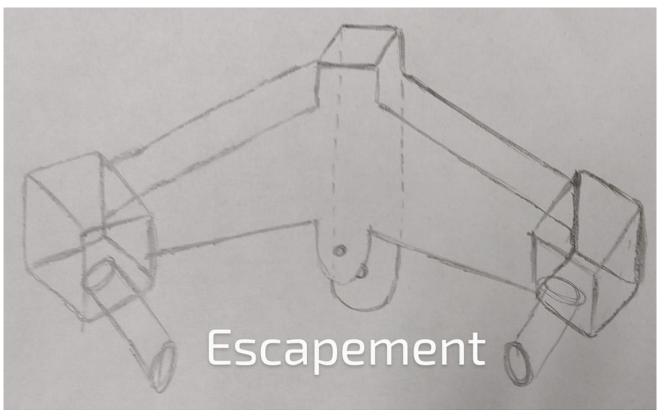
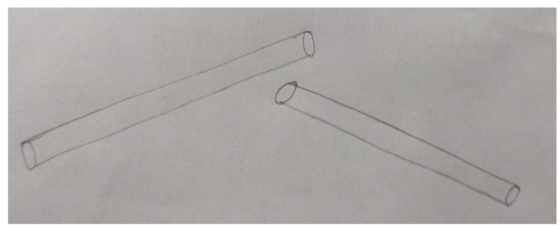
|  |  |
| Fig 15, Escapement (Rough Sketch) | Fig 16, Spindles |

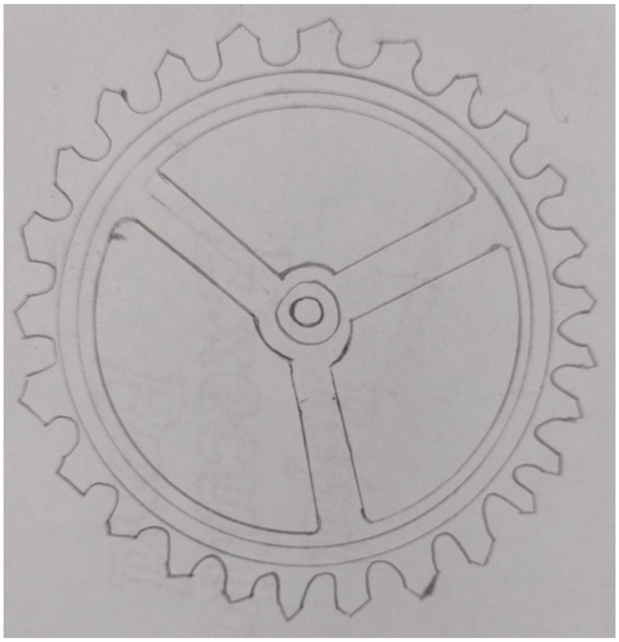


Fig 17, Gear (Connected with the main gear of Pendulum)

## 1. Escapement:

### Structure and Functions

Escapement is the device that permits controlled motion, usually in steps. An **escapement** is a mechanical linkage in mechanical watches and clocks that gives impulses to the timekeeping element and periodically releases the gear train to move forward, advancing the clock's hands. The escapement is driven by force from a suspended weight, transmitted through the timepiece's gear train, which is also designed below. Escapements are also used in other mechanisms besides timepieces. Manual typewriters used escapements to step the carriage as each letter (or space) was typed.

### Modeling and Possible Challenges

Trace type of function may be used to sketch this part. Pendulum Pallets and Pivots points have to be taken care of. The Escapement part is quite important and requires more detailing in all the 3 dimensions. So, it is quite difficult to sketch this part on the Inventor. Little errors will also cause difficulties in the Assembly Section, which we all do not want. The Gear Part also has a different design than the regular gear designs. So, it is quite difficult to design that on Inventor. Smooth Rotation and Precision is the most important requirement for the Assembly Section.

### References


1. https://en.wikipedia.org/wiki/Escapement

# 2. Gear:

## Structure and Functions

This gear provides the torque which is necessary for the pendulum to rotate.

## Modeling and Possible Challenges

The Gear Part also has a different design than the regular gear designs. So, it is quite difficult to design that on Inventor. Smooth Rotation and Precision is the most important requirement for the Assembly Section.

## References

1. https://www.thomasnet.com/articles/machinery-tools-supplies/understanding-gears/#:~:text=Gears%20are%20used%20to%20transfer,the%20output%20speed%20or%20torque.

# Detailing of following parts done by Sonalika (22110151):

# Parts:

- Gear
- Ratchet
- Pawl

## 1. Gear

### Introduction

Gears are essential for regulating and controlling the movement of a mechanical pendulum. To convey power and modify the speed or direction of rotational motion, gears are toothed wheels or cogs that mesh with one another.

### Structure and functions

The gear connected to the ratchet and pawl in a mechanical pendulum consists of a toothed wheel that meshes with the pawl and interacts with the ratchet. Around its perimeter, it has teeth that are uniformly spaced. The gear has two purposes. In the first place, it regulates the pendulum's oscillation by permitting rotation in one direction while prohibiting movement in the opposite direction. The pawl interacts with the gear's teeth as the pendulum swings, allowing for this selective rotation. The gear also controls how much energy the pendulum mechanism uses. It makes sure that the pendulum's swinging motion is communicated to other parts or mechanisms connected to the ratchet and pawl, facilitating particular actions or functions in the larger mechanical system. The mechanical pendulum's overall functionality and performance are influenced by the precise design of the gear and its interactions with the ratchet and pawl.

### Possible challenges

I might run into a number of difficulties while researching the gear that is attached to the ratchet and pawl in a mechanical pendulum. It can be challenging to comprehend the complex mechanics of the gear system and how it interacts with the ratchet and pawl. An in-depth comprehension of mechanical engineering principles is necessary to analyze the forces, torques, and timing involved in the gear's operation.

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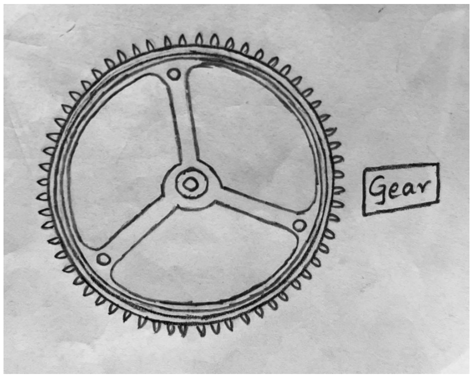
|  |  |
| Fig 18, Gear (Rough Sketch) | Fig 19, Gear (Original Look) |

## 2. Ratchet

### Introduction

The ratchet is a part of a mechanical pendulum that is important in regulating the direction and motion of the pendulum. Typically, a ratchet is a wheel or bar with equally spaced teeth or notches running the length of it. The ratchet is essential for regulating and managing the mechanical pendulum's oscillation, resulting in a predictable and controllable movement pattern. It contributes to the general functioning and operation of the pendulum system by assisting in maintaining the proper direction of motion and preventing any undesirable reversals.

### Structure and functions

The ratchet in a mechanical pendulum is a component that consists of a notched wheel or bar. Along its length, it has equally spaced teeth or notches that make up its construction. The primary roles of the ratchet in the pendulum system are directional control and energy management. The pawl, a little lever or catch, interacts with the ratchet's teeth when the pendulum swings. This engagement prevents the pendulum from moving backward while allowing it to swing in a particular direction, usually in the forward swing. The ratchet's teeth serve as a locking mechanism, making sure that the pendulum doesn't swing backwards. The ratchet also aids in controlling the flow of energy within the pendulum system. It enables the pawl to latch onto the teeth and store potential energy during the back-and-forth motion of the pendulum. This power can be used to operate specific tasks inside the broader mechanical system or to drive other related components. Overall, the mechanical pendulum's controlled motion and energy dynamics are influenced by the construction and function of the ratchet.

### Possible challenges

While studying the ratchet present in a mechanical pendulum, I might face a number of difficulties. It can be difficult to comprehend the complex physics of the ratchet mechanism, including tooth engagement and disengagement.

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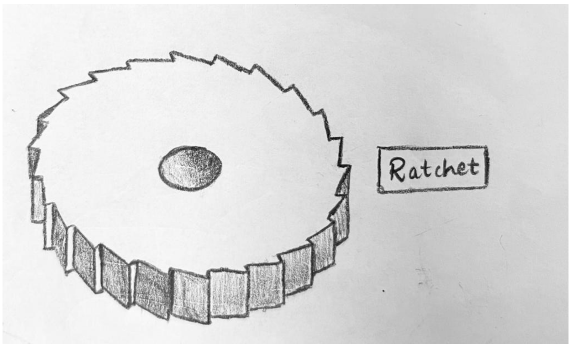
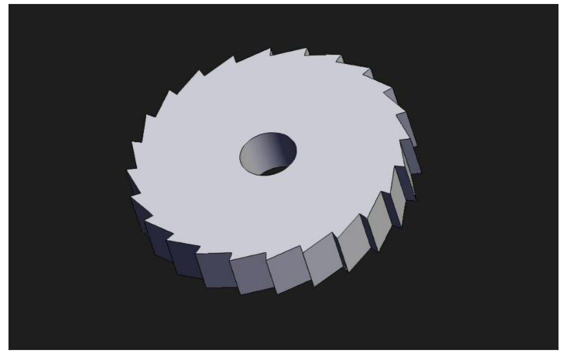
|   |  |
| Fig 20, Ratchet (Sketch) | Fig 21, Ratchet (Original Look) |

# 3. Pawl

## Introduction

The pawl is a key element of a mechanical pendulum that works in conjunction with other parts, like the ratchet or gear, to regulate the pendulum's motion and operation.
The pawl serves as a locking device that allows the pendulum to swing only in one direction. As the pendulum swings, it releases one tooth or notch and shifts to the next, enabling continuous motion in the desired direction.

## Structure and functions

The pawl is a small lever or catch that is an essential component of the mechanical pendulum system. The pawl is often a tiny, hinged lever that fits into the ratchet wheel or bar's teeth or notches. It can move up and down or side to side because of a pivot point or axle. In a mechanical pendulum, the pawl's main job is to regulate the pendulum's direction and motion. The pawl interacts with the ratchet's teeth or notches when the pendulum swings. This interaction enables the pawl to latch onto the ratchet and stop the pendulum from swinging the other way. The pawl functions as a locking device, allowing the pendulum to swing forward but preventing it from swinging backward. The pawl switches from one notch to the next when the pendulum swings, enabling the pendulum to continue moving in the desired direction. Overall, the pawl's form and function ensure the mechanical pendulum moves in a controlled and regulated manner, which helps to assure its optimal functionality.

## Possible challenges

There are a number of difficulties I could run into when researching the pawl found in a mechanical pendulum. It can be challenging to comprehend the complex mechanics of the pawl, including how it interacts with the ratchet teeth. It might be difficult to design and optimize the pawl for accurate and consistent movement while taking into account variables like clearance, wear, and longevity.

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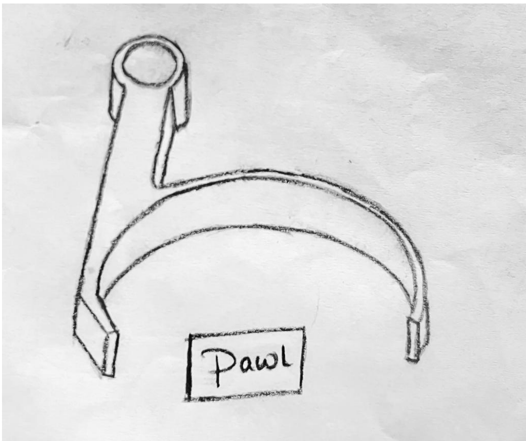
|  |  |
| Fig 22, Pawl (Sketch) | Fig 23, (Original Look) |

# Detailing of following parts done by Mihika Desai (22110152):

- Key Shaft
- Intermediate gears
- Drum

## 1. Key Shaft

### Introduction

The key shaft is a vital component of our mechanical clock, connecting the winding key to the main spring. It transfers rotational energy during winding, storing potential energy for powering the clock's movement. Challenges in designing the key shaft include determining appropriate dimensions and material selection. Its significance lies in its role as the interface for users to engage with and power the clock.

### Uses

The key shaft is essential in mechanical clocks with winding mechanisms, facilitating the transfer of energy from the winding key to the main spring. It enables clock winding, ensuring ongoing operation and accurate timekeeping.

### Potential Challenges

Designing the key shaft in Autodesk or other software may pose challenges in accurately representing its dimensions and simulating material properties. Achieving compatibility with the winding mechanism requires precise design. Design challenges include accurate representation and compatibility, while its significance lies in functionality and user engagement.

### Function

The key shaft's significance lies in its critical role within the clock's mechanism and as the connection between users and the clock.
In conclusion, the key shaft is a crucial component, transferring energy during winding and enabling clock operation.

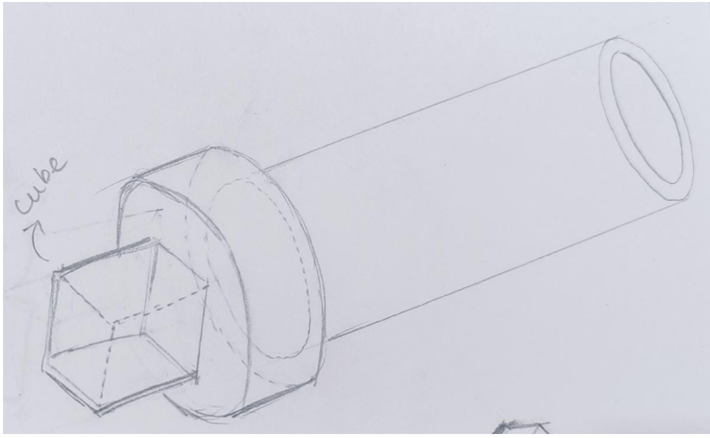



Fig 24, Key Shaft

# 2. Gear

## Introduction

Gear 30 is a fundamental component of our mechanical clock, serving as an intermediate gear within the gear train system. It facilitates the transmission of rotational motion from one gear to another, contributing to the smooth operation and accurate timekeeping of the clock. Challenges in designing Gear 30 include determining the appropriate tooth count and ensuring precise meshing with adjacent gears. Its significance lies in its crucial role in regulating the movement of the clock's hands.

## Modeling

Designing Gear 30 in Autodesk or other software involves carefully considering its dimensions, tooth profile, and material selection. Accurate modeling and manufacturing techniques are required to achieve the desired functionality and ensure compatibility within the clock's gear system.

## Uses

Gear 30 plays a vital role in the gear train system of the mechanical clock. It transfers rotational motion from one gear to another, enabling the synchronization of various components and the accurate movement of the clock's hands.

## Potential Challenges

Designing Gear 30 requires precise calculations to determine the appropriate tooth count, module, and pressure angle for optimal gear meshing. Ensuring the correct spacing and alignment with adjacent gears can be challenging. Additionally, the manufacturing process for Gear 30 must maintain high accuracy to ensure smooth and reliable performance.

## Function

Gear 30 is significant as it acts as an intermediate gear, transmitting rotational motion between different gears within the clock's mechanism. Its precise design and proper functioning contribute to the overall accuracy and functionality of the clock, ensuring reliable timekeeping.

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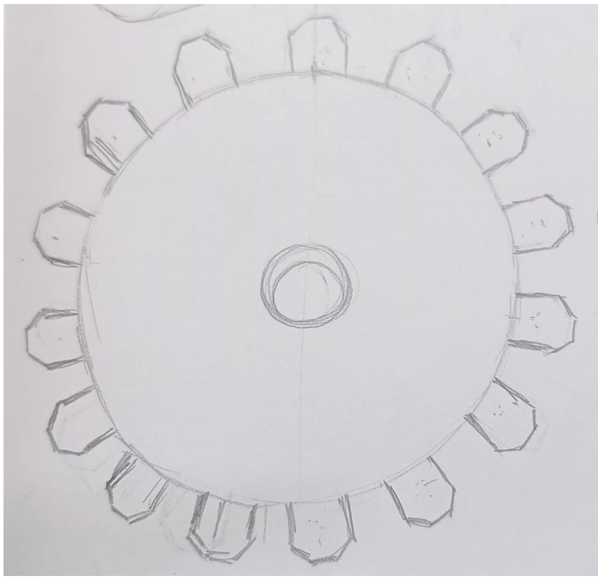
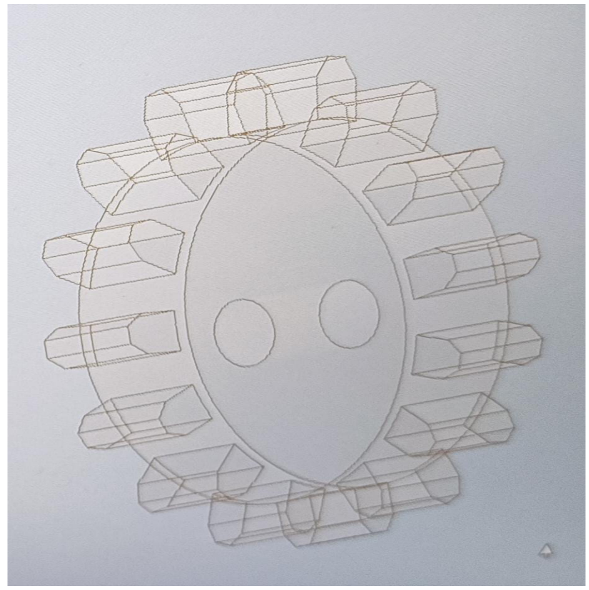
|  |  |
| Fig 25, Gear | Fig 26, Gear |

# 3. Drum

## Introduction

The drum is a vital component of our mechanical clock, responsible for storing and releasing the energy needed to power the clock's movement. It serves as a reservoir for the clock's power source, such as a wound spring or weights, and plays a crucial role in regulating the clock's timekeeping accuracy. Challenges in designing the drum include determining the appropriate size, shape, and material to ensure proper energy storage and release. The drum's significance lies in its ability to provide consistent power to the clock's mechanism, enabling reliable and precise timekeeping.

## Uses

The drum serves as a reservoir for the clock's power source, storing the energy needed to drive the clock's movement. It releases this stored energy in a controlled manner to ensure consistent and precise timekeeping. The drum is an essential component that enables the clock to operate continuously and accurately.

## Challenges

Designing the drum requires careful consideration of its size and shape. The drum must be designed to effectively store and release energy, avoiding issues such as excessive friction or energy loss. Ensuring proper alignment and interaction with other components, such as the gear train and escapement mechanism, can also present challenges. Additionally, manufacturing a drum that meets the required specifications and tolerances can be a complex task.

## Function

The drum is significant as it stores and releases the energy required to power the clock's movement. Its proper design and functioning are crucial for maintaining consistent power supply, ensuring accurate timekeeping, and allowing the clock to operate reliably. The drum's ability to store and regulate energy contributes to the overall functionality and performance of the mechanical clock.

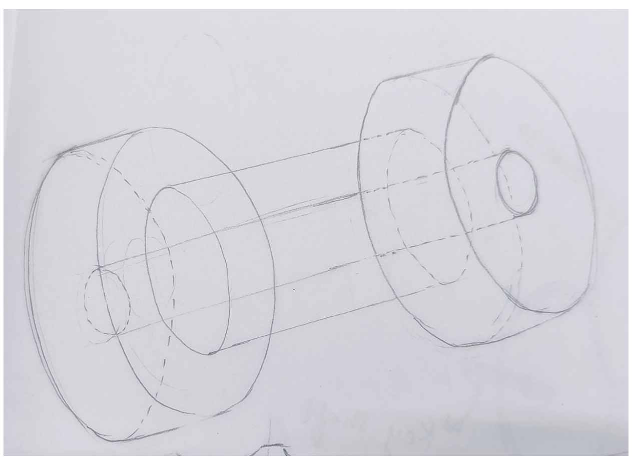


Fig 27, Drum

## References


1. https://grabcad.com/library/mechanical-clock--1

# Detailing of following parts done by Sai Charan (22110153):

- Frames(x2)

## Introduction

Pendulum clocks are mechanical timekeeping devices that are controlled by a swinging pendulum.To protect the fragile gears and mechanisms inside a pendulum clock, they are often enclosed within frames.These frames, also known as clock plates or gear covers, serve numerous functions, including structural support, minimizing dust and debris accumulation, and improving the clock's aesthetic appeal.
The frames that cover the gears of a pendulum clock are typically made of metal, such as brass or steel, and are custom-built to meet the clock's exact dimensions and shape. They are made up of two primary parts: the front plate and the back plate. The front plate is the visible component of the clock that is usually ornately designed and may be ornately decorated. The gears responsible for conveying motion from the pendulum to the clock's hands are precisely positioned within the frame.

The frame performs several functions in the pendulum clock's operation. For starters, it gives the gears and other components structural support, ensuring that they remain aligned and in the proper place. This stability is required for the clock's hands to move accurately and consistently. Furthermore, the frame serves to reduce the impacts of external elements such as vibrations or unexpected movements, which could otherwise impair the operation of the clock.Furthermore, the frame functions as a barrier, keeping dust and debris out of the clock's mechanism. This is critical because even little particles might interfere with the delicate interaction of the gears, resulting in errors or even complete clock malfunction. The frame aids in the preservation of the clock's precision and dependability over time by protecting the gears.Finally, the frames that hide the gears add to the overall aesthetic appeal of the pendulum clock. Clockmakers frequently create and adorn these frames with complex patterns, engravings, or other embellishments that enhance the timepiece's visual appeal. The front plate, in particular, highlights these creative aspects, transforming the clock into both an attractive aesthetic object and a functional timekeeping instrument.

In summary, the frames that shield the gears in a pendulum clock provide structural support, prevent dust accumulation, and enhance the clock's visual appeal. They help to maintain the precision and endurance of the clock's movement while also adding to its overall aesthetic Appeal.

## Modeling

We start by creating a new project in Autodesk Inventor and set the appropriate units and measurements for the clock design.We sketch the basic outline of the frame using 2D sketch tools considering the overall dimensions and shape of the frame. We use lines, arcs, rectangles, and other sketching tools to create the desired frame shape.Once the sketch is complete we use the extrusion feature to convert the 2D sketch into a 3D frame. By specifying the desired thickness or depth of the frame during the extrusion process. We add fillets to smooth out sharp edges or add decorative details.Verify whether any other components are interfering. Perform a finite element analysis to evaluate the structural quality. Create precise drawings for documentation, add annotations and dimensions, and complete the design. The design should be saved and exported in the proper format.

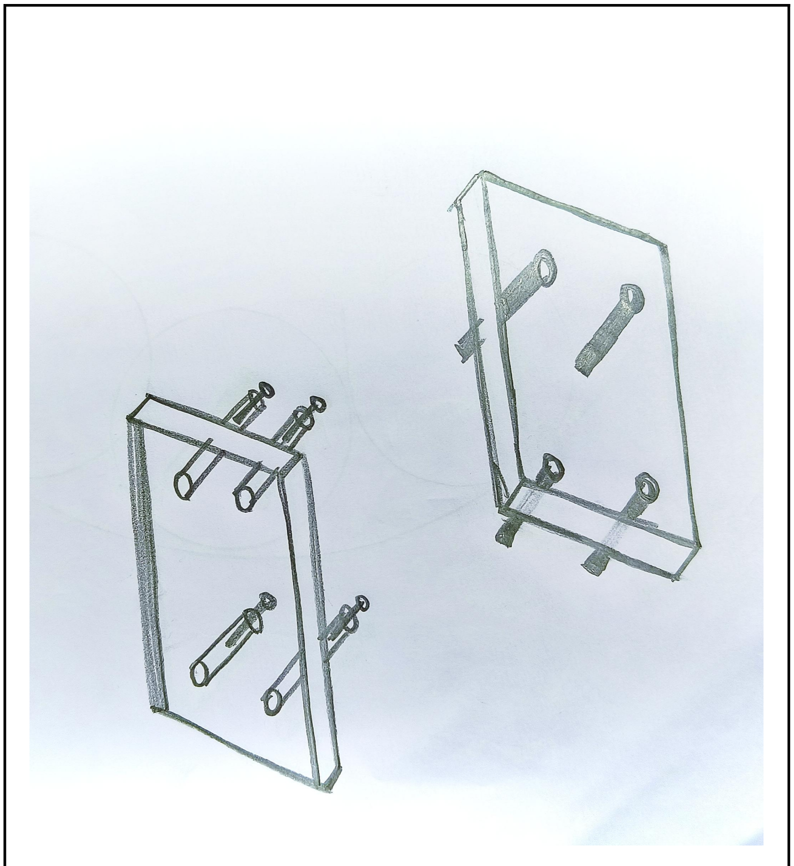


Fig 28, Frames (3D View)

## Potential Challenges

It might be difficult to create an intricate and accurate frame for a pendulum clock.The frame may have multiple components, intricate details, and precise measurements. Ensuring the design is both aesthetically pleasing and functional requires careful attention to detail.

Pendulum clocks have moving parts that need to work harmoniously. Aligning the frame components correctly to allow for smooth movement of the pendulum and other mechanisms can be a challenge. You'll need to consider the interplay between various parts and ensure proper clearances and tolerances.

We may have difficulty accurately visualizing the finished product while designing the frame in Autodesk Inventor. Within the software, it might be difficult to achieve a true approximation of the frame's look, including textures, finishes, and complex details.

As we have attended only two lab sessions, I cannot predict more difficulties that I could incur. To overcome these challenges, it's essential to have a strong understanding of Autodesk Inventor's tools and features.

## References:


1. https://grabcad.com/library/mechanical-clock--1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