**Parabola Volume 59, Issue 1 (2023)**

# Constructing a 20-year mechanical calendar

**Aadit Jain**[1]

## 1 Introduction

I always wondered how Google could show me the day of my next birthday. I didn't know any computer languages and was in a state of confusion. As Albus Dumbledore once said, "When in doubt, I find retracing my steps to be a wise place to begin." Taking inspiration, I created a 20-year Mechanical Calendar using elementary school mathematics!

## 2 Mathematics behind the Calendar

Although remainder and quotient have always both been part of division, we have always discriminated between them. Remainder has mostly been considered an underdog – but this project recognises its true potential. The remainder (or *mod*) is a very useful tool commonly used in computer programming. This is the operation of dividing by one number by another and recording what is left over.

For example, $18 \mod 7 = 4$ since the remainder of $18$ divided by $7$ is $4$.

Since the days of the week repeat every 7 days, I used $\mod 7$ to obtain the day of a given month and year. For example, if we know that 1 January 2010 was a Friday, then can we easily tell what day 1 January 2011 was? There are $365$ days in a normal year, and $365 \mod 7 = 1$. Hence, 1 January 2011 was a one day more than Friday, that is, a Saturday. What about leap years? There are $366$ days in a leap year, and $366 \mod 7 = 2$. Therefore, if 1 January 2012 were a Sunday, then 1 January 2013 would have been a Tuesday. Similarly, we can calculate the shifts in days between months.

## 3 Construction of the model

The logic described above was used to construct the Mechanical Calendar. Two pairs of pulleys were constructed: a year pulley (Figure 1) and a month pulley (Figure 2). The year pulley calculates the shifts in days between years while the month pulley calculates the shifts in days between months.

[1]Aadit Jain (aaditdjain@gmail.com) is a high school Student at Rancho Bernardo High, San Diego, CA, USA.

The days were written on a circle which was divided into $7$ arcs of equal length. The space between $2$ consecutive years was set according to the mod $7$ of the number of days between them. For instance, there was a space of $1$ unit between 2010 and 2011. However, the space between 2012 and 2013 was $2$ units as there are $366$ days between the two years. When the year is changed, the rotating pulley points towards the desired day.

The month pulley was divided into 2 sections: leap year and non-leap year. The spacing between $2$ consecutive months was set according to the mod $7$ of the number of days between them. For instance, there is a space of $3$ units between 1 January and 1 February (non-leap year) as $31 \mod 7 = 3$.

Finally, both the pulleys were combined to create the model as shown in Figure $3$. I started with 1 January 2010, known to be a Friday, and then moved all the way up to 2030 for the actual model. Due to space constraints, the modelling diagrams only show between 2010–2020. So, with this method, we can find the $1$st day of any desired month/year, and then there are only $7$ possible monthly calendars to choose from.

## 4 Summary

As can be seen, a rotation motion of pulley is equivalent to calculation of remainder, and this basic observation along with some simple mathematics was exploited to construct this device. The mathematics used in this project is used worldwide in all computer programs to show us the particular day of a particular day.

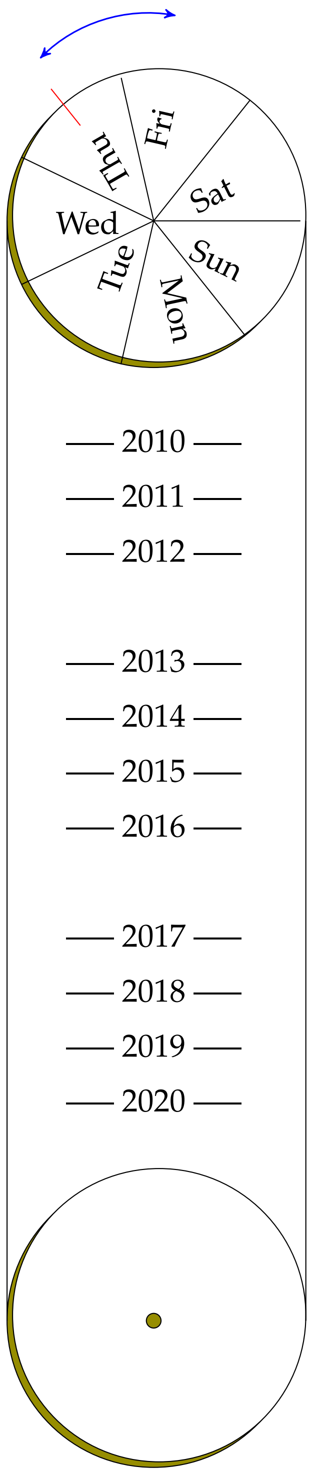
We have been using maths and physics to construct simple and complex machines, and this was an example of a simple but really rewarding one. It provided a solution to my observation of getting the day of any date on Google and illustrated how simple things can be utilized creatively!

## Acknowledgements

I gratefully thank Thomas Britz for his insightful corrections and suggestions which significantly improved the presentation of this article!

# Individual Pieces

Moving the pointer 1 year down rotates the day pulley clockwise by 1 day for non-leap years and 2 days for leap years




Moving the month pulley pointer down rotates the day pulley clockwise by difference in days between 1st of consecutive months; e.g., Jan-Feb is 3 days; Jun-Jul is 2 days.

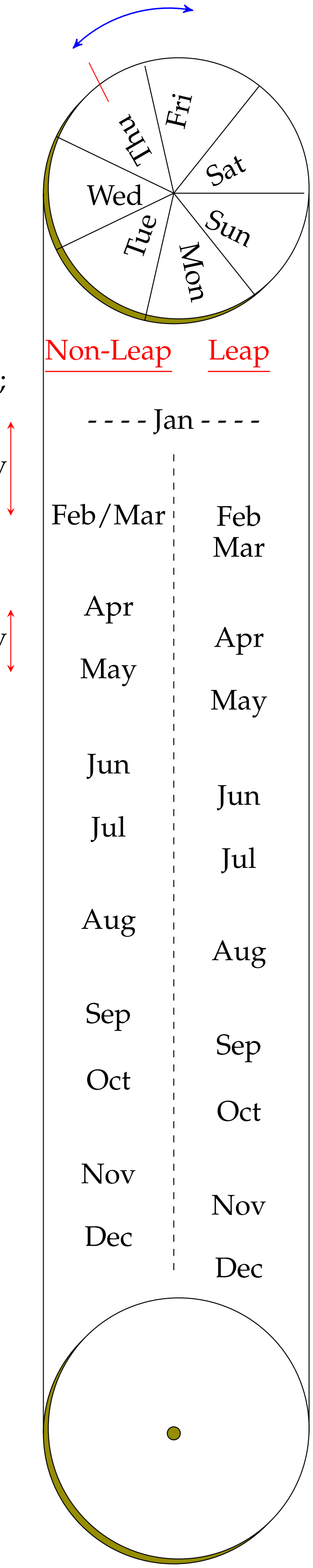





Figure 1: Year Pulley

Figure 2: Month Pulley

## Combined System

To find the 1st day of the required month, follow the below steps:

1. Put the Interchangeable pulley to Year-System. Move to desired year. This rotates the day to 1 Jan of that year.

2. Next, put the interchangeable pulley to Month-System; this moves the month to desired month of the chosen year.

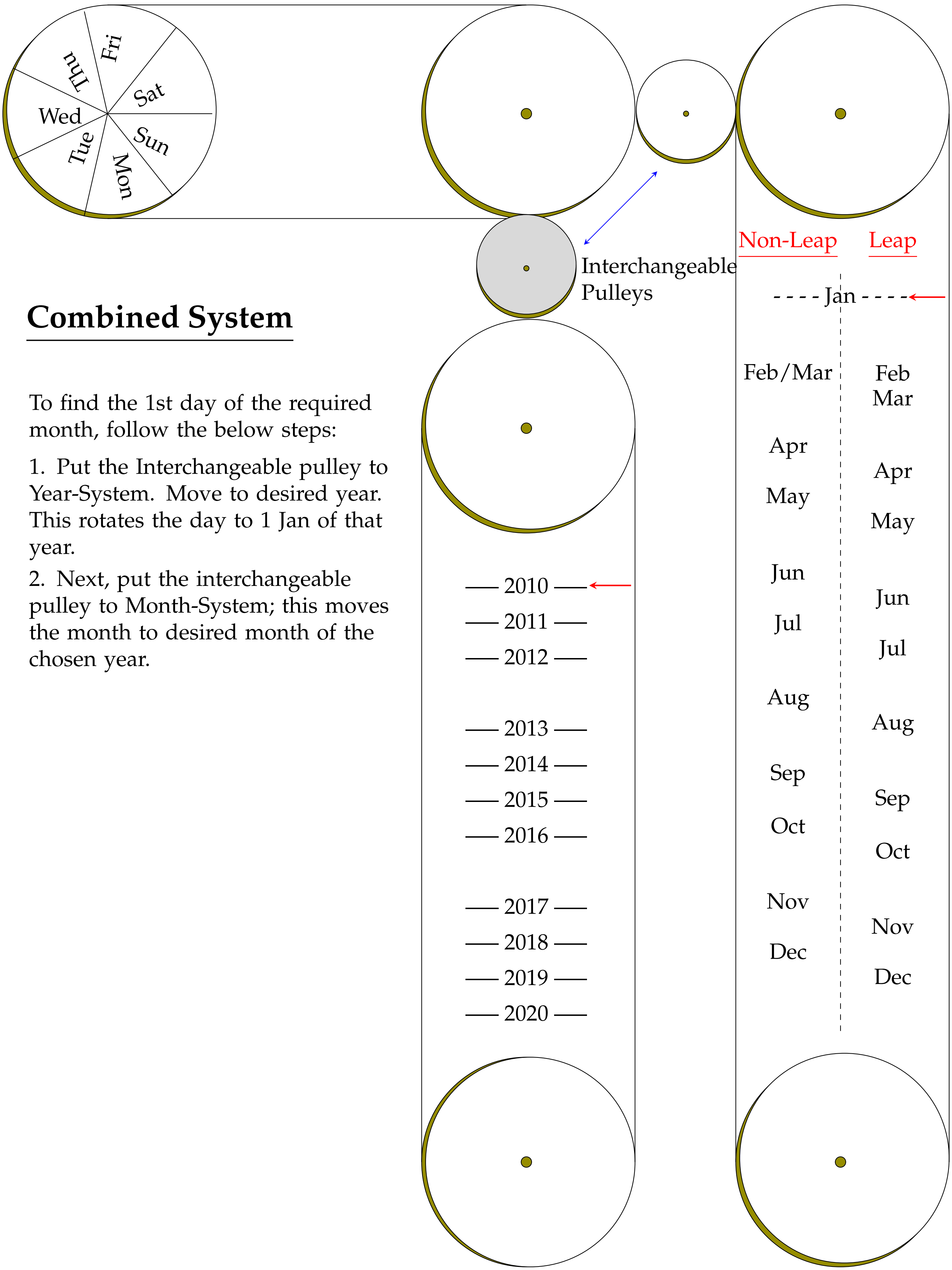



Figure 3: Combined System

# Actual Model

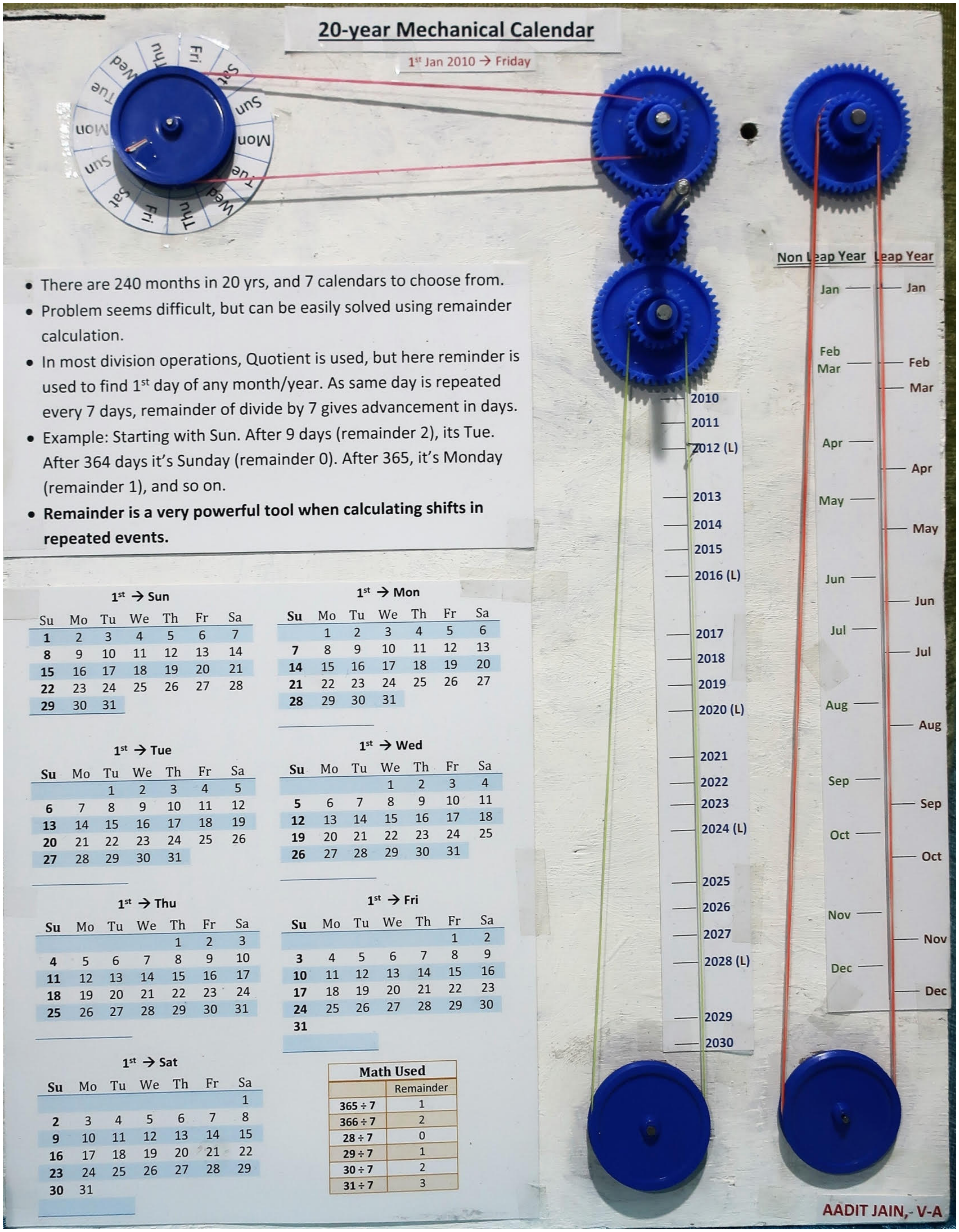



Figure 4: Actual model