Happy Birthday POW: SPAR

By: Rohan, Svasti, Aishani, Parnitha Section B

Problem Statement: The goal of this project is to find out what day of the week someone was born based on the date of their birth.

We have some limitations/constraints:

- Only allowed to use a basic calculator
- Only allowed to reference our dates based on the calendar of October 2025
- Must take leap years into consideration

We were given the following items:

- The number of days in each month
- The birthdays of famous people and the day of the week they were born

Since the last of the major changes to the Gregorian calendar were made before the year 1900, our model is **only applicable to dates from 1900 on**.

So by using these resources and analyzing dates over time, we need to find a method to find the day of the week for any day after 1900.

Process

Considerations

- Every 4 years, there is a leap year with 366 days where February has 29 days rather than 28
- Leap years occur in years divisible by 4 (1904, 1908, 1912...)

- 1900 is not a leap year as it is divisible by 100 but not 400. For example, 1200, 1600, and 2000 were leap years. 1700, 1800, 1900 were not.

Initial Thoughts

- We started by identifying two possible methods
    - Start from the current date
        - Uses the days elapsed since date of birth
        - Uses the current day of the week
    - Start from January 1st, 1900 which is the first possible birthday for this problem
        - Uses the day of the week of January 1st, 1900
        - Uses the days elapsed from January 1st, 1900 to the birthday

Which one did we choose?

We choose to start from January 1st to make it easier to find the months elapsed.

- If we started from the current date, we would have to calculate the month elapsed from the birth month to October. This would also make calculating the months elapsed more difficult for birthdays in November and December, since one would be unable to just subtract to find months elapsed.
- By starting from January 1st, 1900, we were able to make the process easier by only needing the birth month, instead of the current month and birth month.

To get started with this method, we needed to find the number of days elapsed from January 1st, 1900 to the birthday.

Step 1-Find what day of the week was January 1st, 1900

1a. Used Louis Armstrong's birthday as a reference since his was the closest

- We know he was born on August 4th, 1901, and on a Sunday.
- We also know that 1900 is not a leap year because it is divisible by 100 and not 400, so it had 365 days

1b. Count the number of days between January 1, 1900 and August 4 1901

- Jan 1 1900 to Jan 1 1901 = 365 days
- Jan 1 1901 to Aug 4 1901 = 215 days
- 215 + 365 = 580 days passed between Jan 1 1900 and Aug 4 1901

1c. Figure out how many "extra" days there are after counting for weeks

- There are 7 days in a week, so we can divide by 7 and see what remainder we get. Or more simply, do mod 7

580/7 = 82 remainder 6

OR

580 mod 7 = 6

- The remainder, 6, represents that August 4 1901 is 6 days later in the week than January 1 1900

1d. Use the weekday we know and go backwards

- August 4 1901 = Sunday
- Sunday - 6 days = Day of the week for January 1 1900
- 6 days earlier than Sunday is a Monday
- **So, January 1st, 1900 was a Monday**

Step 2- Calculate the number of days from January 1st, 1900 to the birthday

2a. Calculate the number of days of full years from 1900 to the year of birth.

Subtract 1900 from the current year.

-This is to find the number of years that have passed since 1900

Multiply this number of years by 365.25 and then floor the product. But, why?

- So first, we realized that we had to account for the leap year occurring every four years.

- Theoretically, each year is 365.25 days, meaning that the number of days will only be correct every 4 years. So for years not divisible by 4, the extra part of a day will not count. Therefore, we decided to floor the product to make sure the extra day was only counted when the cycle of 4 years was complete.

$$\lfloor 365.25 \left(\text{Birth Year} - 1900\right) \rfloor$$

Notice, how this does not count the days of the birth year itself, resulting in the need for further calculations.

2b. Calculate the number of days of full months from the start of the birth year to the start of the birth month

-Since each month has a different amount of days, it was difficult to identify a specific formula to calculate the total months elapsed.

-Thus, we decided that it would be the most beneficial for the user to calculate the days elapsed in the year. However, the user does not want to include the month the birthday occurred on, as it will be incomplete.

-For this step, calculate the number of days elapsed by adding all of the months from the start of the year to one before the birth month. Assume February to be 28 days no matter the year, as leap year days are included in the days from years calculations.

Days in every Month

January	February	March	April	May	June	July	August	September	October	November
31	28	31	30	31	30	31	31	30	31	30

$$\sum \left(\text{Days per month till} \left(\text{birth month} - 1\right)\right)$$

-This gives the number of days in the birth year excluding the birth month.

2c.

Now, we just have to add the remaining days of the birth month, by just adding the day the subject was born.

This overall, gets us the total days elapsed since Jan 1st, 1900.

$$\left\lfloor 365.25 \left(\text{Birth Year} - 1900\right) \right\rfloor + \sum \left(\text{Days per month till} \left(\text{birth month} - 1\right)\right) + \text{Day born}$$

However, we discovered that this formula does not find the days elapsed for birthdays that occur before March.

Initial conversations included:

-Is it due to a mistake in calculations(forgetting to add a 1 for inclusivity...)?

-Does it occur every year when referring to birthdays before March?

-Will subtracting 1 as a universal solution work?

This led to discoveries concerning the fact that the formula above, counted the extra day of leap year, even though that extra day was insignificant for birthdays that occurred before it. For example, the formula overcounted by a day for a birthday on February 2nd, 1904 since it included the extra leap day (reference year formula), despite it not occurring. Therefore, we created a piecewise function to handle the exceptions.

Does the Birthday occur on a leap year AND Happen before March 1st

$$\begin{cases} \text{Yes:} & \lfloor 365.25\,(\text{Birth Year} - 1900) \rfloor + \sum \left(\text{Days per month till } (\text{birth month} - 1)\right) + \text{Day born} - 1 \\ \text{No:} & \lfloor 365.25\,(\text{Birth Year} - 1900) \rfloor + \sum \left(\text{Days per month till } (\text{birth month} - 1)\right) + \text{Day born} \end{cases}$$

-We subtract one day to remove the effects of the extra day from the year formula.

3. Use the days elapsed to find the day of the week of the birthday

Now, to find the day of the week, we realized that we would need to use the modulo operator. This operator allows one to calculate the cycles of the days of the week, with the use of modulo 7. Essentially, this means that a loop occurs after every 7th term, referring to the 7th day of the week. To get the final day, we would have to find the elapsed days mod 7, leading to information about the birth day.

Does the Birthday occur on a leap year AND Happen before March 1st

Yes:

$$\left(\lfloor 365.25\,(\text{Birth Year} - 1900)\rfloor + \sum(\text{Days per month till (birth month} - 1)) + \text{Day born} - 1\right) \% \, 7$$

No:

$$\left(\lfloor 365.25\,(\text{Birth Year} - 1900)\rfloor + \sum(\text{Days per month till (birth month} - 1)) + \text{Day born}\right) \% \, 7$$

Each result corresponded with a different day of the week.

Each response, after using modulo, corresponded with a day of the week.

0 = Sunday 1 = Monday 2 = Tuesday 3 = Wednesday 4 = Thursday 5 = Friday 6 = Saturday

Solution:

Subtract 1900 from your birth year

Multiply this number by 365.25

Round this number down

Now, add the number of days in the months before the month you were born using the key below:

January - 31 days February - 28 days March - 31 days April - 30 days May- 31 days June - 30 days

July - 31 days August - 31 days September - 30 days October - 31 days November - 30 days

For example, if you were born in March, you would add 31 and 28.

Next, add the day you were born

If you were born in a leap year in January or February, subtract your number by 1

Leap years are years that are divisible by 4. If a year is divisible by 100 but not 400, it is not a leap year.

Mod 7 the resulting number

Use the key below to figure out which day you were born:

0 = Sunday   1 = Monday   2 = Tuesday   3 = Wednesday   4 = Thursday   5 = Friday   6 = Saturday

Here is an example using - Cullen Jones (Feb 29, 1984)

$1984 - 1900 = 84$

$365.25(84) = 30681$

$30681 \ after\ rounding\ down$

$30681 + 31\ (January) = 30712$

$30712 + 29 = 30741$

$Since\ 1984\ is\ a\ leap\ year\ we\ subtract\ 1\text{:}\ 30741 - 1 = 30740$

$mod7\ (30740) = 3$

According to our key, 3 is a wednesday!

Cullen Jones was born on Wednesday, February 29th, 1984.

Extensions:

1) Find a formula that works for birthdays before 1900:

Years that are divisible by 100 (but not 400) are not a leap year. This means the year 1900 is not a leap year. How would you find a formula that accounts for these types of years?

To take it a step further, years that are divisible by 400 are leap years (even though it is divisible by 100). How would you account for these years?

A potential method could be to use a piecewise function. You could tell people to use a different function depending on whether their birthday is before, on, or after 1900.

Lastly, how will changing the "baseline" date of the formula to account for birthdays before 1900 affect the formula? In our solution, we use January 1, 1900 as the baseline date, which can be seen in the term (birth year-1900). Will simply replacing 1900 with the preferred year in (birth year - 1900) be all that is needed? By doing this, are you discounting the fact 1900 is not a leap year?

2) Find a formula that works to find days of the week for birthdays in other calendar systems:

For example, lunar calendars are still used around the world. These types of calendars typically have 29 days in a month, following the lunar cycle. How will the formula change if basing it off a lunar calendar system?

For this, you can assume that there are 29 days in a month; 7 days a week still following the Monday, Tuesday, Wednesday pattern; and 348 days a year. You can disregard leap years as olden lunar calendars didn't have them either.

3) Can only one formula (no piecewise functions) be used to solve the original question?

In our solution, we had a piecewise function with two different formulas. One for birthdays before March 1 on a leap year, and one for all others. So, is it possible to find only one formula that accounts for all birthdays after January 1, 1900. If not, can you prove why it is not possible?

4) What is the best number to multiply with (birth year -1900)?

In our solution, we multiply the number of days in a year with the number of years since 1900 to find the amount of years, in days, that have passed. We use the number 365.25 days in a year because there are 365 days in a year and 366 days every 4th year. This averages out to 365.25 days per year. However, this number only accounts for leap years that are a quadruple of 4. In reality, our calendar system has a leap year every 4 years, *no* leap year every 100th year, and a leap year every 400th year. So, what is the most accurate number to use for days in a year?