Happy Birthday Problem

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Problem Statement:

Oh no! Jigsaw has locked you in a room with only a calculator and a friend. In order to escape, you must calculate what day of the week they were born on. How can you survive?

Process:

While brainstorming about the POW, we came to an initial conclusion: in order to find what day of the week a date was on, we needed to find the number of days separating it from a date we already knew. We started by breaking down this objective into smaller parts, first calculating the number of leap days between the two dates. Since there is one leap year every four years, we divided the difference of years by four to find the number of leap days. Next was to determine the days, excluding leap days, between the current date and the birthday. We tried various approaches such as calculating the number of days since the current date directly, and also finding the difference by comparing the days since the bottom limit of January 1st, 1900 of the dates. By adding this value with the number of leap days, we could calculate the total day difference. Using the day difference, we subtracted it from the current day of the week, represented by a number (0-6), and then divided by seven. The remainder of this, a value 0-6, represented the week day. However, this process was very complicated, so our next objective was to simplify it. With the help of suggestions from other groups, we realized that we could just use the weekday of the bottom limit, instead of the current date. Doing so would remove the step of having to calculate the days since 1900 of the current date. Using our old process, we found

the weekday of 1/1/1900 to be Monday, or 1. By using this value, we simplified our formula to only find the days since the bottom limit of the given date.

Solution:

How to find the day of the week of any date (including a birthday!):

1. Let m/d/y represent the date, and let the numbers 0-6 correspond to Sunday-Saturday, respectively.
2. We will find the day of the week by comparing to our bottom limit, January 1st, 1900, which was a Sunday (credit to Nick Giza's group for the suggestion)
3. To find the number of days since the beginning of the year, add d plus the number of days in the previous m-1 together
    a. For example, if the given date is March 10th, add 31 (for January) + 28 (for February) + 10 (for March)
    b. If it is a leap year (y is divisible by 4) and the date is after February 29th, add 1 (credit to Rishi Patel's group for the suggestion)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
31	28*	31	30	31	30	31	31	30	31	30	31

4. Let L_y = the number of leap year days = (the closest leap year before y - 1900)/4
5. Let Δd = the number of days since 1/1/1900 = the number of days since the beginning of the year + 365*(y-1900) + L_y
6. The day of the week is the remainder of Δd when divided by 7
    a. For example, if $\Delta d = 52$, the remainder of 52 divided by 7 is 3, so the day of the week is Tuesday

Here is our reasoning for why this works:

To do this, we basically came to the conclusion that to get the day of the week of a given date, we would have to find the total number of days between 1/1/1900 (beginning of our timeline) and mod that number by 7 (days of the week). With this entire process we would also have to account for the days added on due to leap years in order for it to be completely accurate.

In general we used the equation:

Let:

d = current day of month

m = days leading up to current month

y = current year

c = most recent leap year

$\Delta d = d + m + (y-1900)*365 + (c-1900)/4$

day of the week = the remainder of Δd when divided by 7

In this equation:

- ((c-1900)/4) represents the number of leap year days added on to the total number of days from 1900. This is reasonable due to the fact that a leap year happens every four years so getting the difference of years between 1900 and the current year and dividing it by 4 would give us the number of leap years.
- ((y-1900)*365) represents the number of days in the years between 1900 and the current year (excluding the leap years)

- Dividing by 7 and getting the remainder enables us to grab the total number of days between the 1/1/1900 and the current date and mod it by 7 to get the day of the week.
- Although 1/1/1900 starts on a Monday, so theoretically Δd should be offset by one, Δd should also be one less because it is missing January 1st itself, so these two effects cancel out, meaning we would be able to get the direct week day of the given date
- (d + m + (y-1900)*365 +(c-1900)/4)) represents the Δd as explained above, which again, represents the number of days since 1900.
    - By dividing by 7 and using the remainers we were able to get the remainers of the days of the week/7, meaning we are able to get the week day. For a given week day, we assigned it a possible remainder when dividing by 7. This works due to the fact that we are following the days of the week in the order that they are given:
        - Sunday=remainder of 0
        - Monday=remainder of 1
        - Tuesday=remainder of 2
        - Wednesday=remainder of 3
        - Thursday=remainder of 4
        - Friday=remainder of 5
        - Saturday=remainder of 6

First, we calculated the week day that 1/1/1900 was on (since it's the beginning of our timeline), to later use it to find the day of the week of a given date in the years beyond:

Since we already had the date of today (as of writing this it is 10/11/2023), we are able to work backwards to find the week day of 1/1/1900, by using the equation given above.
From this, we were able to distinguish that 1/1/1900 was on a Monday.

Since we found that 1/1/1900 was on a Monday, we were able to use this to find how the week day of a given date:
In this example we used: 1/26/23 in 2023

Getting the total days from 1/1/1900 by plugging it into the equation:

$\Delta d = (26+((2023-1900)*365)+((2020-1900)/4))$

$\Delta d = (26+44895+30)$

$\Delta d = 44951$

Getting the remainder of Δd when divided by 7 to get the days of the week

44951/7

Remainder = 4

Therefore 1/26/23 landed Thursday

Extensions:
We coded a Java program to automate this process, with a textual user interface to take in user-inputted dates and output the day of the week.

```
Please enter a date between 2100 and 1900 in the format: 'mm/dd/yyyy'
13/10/2020
Please submit a date with the correct format.
Please enter a date between 2100 and 1900 in the format: 'mm/dd/yyyy'
03/01/2020
Sunday
Would you like to exit? Y/N
n
Please enter a date between 2100 and 1900 in the format: 'mm/dd/yyyy'
02/24/2020
Monday
Would you like to exit? Y/N
n
Please enter a date between 2100 and 1900 in the format: 'mm/dd/yyyy'
10/12/2023
Thursday
Would you like to exit? Y/N
y
```

The program ensures correct date formatting and accounts for leap years to get the correct day of the week.

Possible variations

- How to guess someone's birth year given their birth day and month and their birth day of the week
- Expanding the method to account for leap year rules during centuries
- Expanding the method to BCE
- Expanding the method to different calendar systems