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**Problem Statement:**

Calculate the day of the week you were born using your birth date (i.e. September 24th, 2001). You must do this using only the calendar for the current month and a four-function calculator (basic arithmetic).

**Process:**

1st Attempt:

Steps:

1. Take the number of days in your birth month and subtract the day of your birthday. This will give you a number that represents the day of the week on which you were born.
2. Take the number found in step 1 and divide it by 7.
3. Take the remainder found in step 2 and multiply by 7 to get the number representing the day of the week that you were born on as a number between 0 and 6, including 0 and 6.
4. This number corresponds to the day of the week you were born on, assuming that 0 is Sunday, 1 is Monday, and so on until you get to 6 which is Saturday.

For example, we tested this on Louis Armstrong (LA). His birthday is August 4th, 1901, which was a Sunday:

1. There are 31 days in August and he was born on the 4th, so 31- 4 = 27
2. 27/4 = 0.8571486…
3. 0.8571486… multiplied by 7 is 6, which would be the day of the week he was born on.
4. The number 6 corresponds with Saturday.

This process failed because it assumes the start of each month lines up with Sunday, and it doesn't take years into account.

2nd Attempt:

One of the group members came up with this method as a solution and tested it out using Matt Damon's birthday. This method yielded the correct result, however, upon double-checking the validity of the method a 2nd time using Marylin Monroe's birthday, it did not work. The steps for this method were as follows:

Steps:

1. Find the difference between the current year and the birth year of the birthday.
2. Divide that difference by 4
3. Round the quotient down. This quotient is the number of leap years.

4. Find the number of regular years by finding the difference between the current year and the birth year of the birthday (in other words the age of the person) - the number of leap years.
5. Plug in these values into 365x + 366y, where x = number of regular years and y = number of leap years.
6. Use the sum from step 6 and divide it by 7 using a long division to find its remainder.
7. The remainder is the day of the week that person was born (Monday = 0, Tuesday = 1…. Sunday = 6).

Test 1: Matt Damon's birthday, October 8, 1970 (Thursday):

1. The difference between the current Matt Damon's birth year

| |
|---|
| Current year: 2024<br>Matt Damon's birth year: 1970<br><br>2024 - 1970 = 54. |

2. The number of leap years
   The difference between the current year and the birth year of the birthday: 54 years.

| |
|---|
| $54 \div 4 = 13.5$ |

3. 13.5 rounded down → 13 leap years

4. The number of regular years:

   Difference between the current year and the birth year of the birthday: 54 years
   Number of leap years: 13 years.

| |
|---|
| $54 - 13 = 41$ regular years |

5. Plug into $365x + 366y$

$$365x + 366y$$
$$x = 41$$
$$y = 13$$
$$365(41) + 366(13) = 19,723$$

6. Divide the sum from step 5 by 7 using Long Division:

$$19723 \div 7 = 2,817\ R4$$

7. Remainder = 4. If Monday was the 1st day of the week, Tuesday was the 2nd day of the week….and Sunday was the 7th day of the week, then Thursday was the fourth day of the week! Therefore, Matt Damon's birthday was on a Thursday, which matched up with what we were given.

   Although this worked for Matt Damon, it did not work for Marylin Monroe.

Test 2: Marylin's birthday: June 1st, 1926 (Tuesday)

1. The difference between the current MM's birth year and the current year.

$$2024 - 1926 = 98 \text{ years}$$

2. Divide the difference from step 1 by 4:

$$98 \div 4 = 24.5$$

3. Round the quotient down from step 2 to find the number of leap years. 24.5 → 24 leap years.

4. Finding the number of regular years via the difference found in step 1 and the number of leap years found in step 3.

$98 - 24 = 74$ regular years

5. Plug into 365x + 366y.

$$365x + 366y$$
$$x = 74$$
$$y = 24$$
$$365(74) + 366(24) = 35,724$$

6. Use the sum found in step 5 and divide by 7 using long division.

$$35794 \div 7 = 5113\,R3$$

7. If Monday was the 1st day of the week, Tuesday was the 2nd day of the week….and Sunday was the 7th day of the week, then Wednesday was the third day of the week! This remainder of 3 suggests that Marylin Monroe was born on a Wednesday which is false as she was born on a Tuesday. Thus, this solution process is wrong.

We concluded that this process failed because it didn't account for the month and day a person was born. As for why Matt Damon's birthday worked, it could have just been correct out of luck.

<u>Assistance:</u>
After XYZ group testing and breaking down the problem with Mrs. Burns, we concluded that:

- The leap years might be the problem
- We need to incorporate the day of the month
- We need to take the total number of days in the year before the birthday into account

This feedback helped us approach the problem in a new way by considering whether the birthday had passed or not in the current year, which can be seen in the 3rd attempt. It also helped us consider the number of days leading up to the person's birthday, which helped us get to our final solution.

3rd attempt:

Steps:

1. Subtract your birth year from last year (this will find your age, potentially being one less than your current age) and multiply by 365.25
2. Add up the number of days in all of the months before your birthday (if your birth year is divisible by 4, it is a leap year, so you should use 29 days for February), plus the date of your birth (see table 1 for the number of days in each month)
3. Add the values from steps 1 and 2
4. Divide your age by 4.
5. Round the quotient down to a positive integer. This quotient is the number of leap years.
6. Find the number of regular years by finding the difference between the current year and the birth year of the birthday (in other words the age of the person), then subtracting the number of leap years from this number.
7. Plug in these values into the equation 365x + 366y, where x = number from step 2 and y = number of leap years.
8. Take that sum and divide it by 7, using a long division, to find its remainder.
9. The remainder found in step 8 is the day of the week that person was born (See table 2).

Table 1:

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

*29 in leap years

Table 2:

| Monday | Tuesday | Wed | Thu | Friday | Sat | Sun |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |

For example, we tested this method using Roald Dahl's birthday, which was Wednesday, September 13, 1916:

1. The difference between RD's birth year and last year.

$$2023 - 1916 = 107$$
$$107 \bullet 365.25 = 39,081.75$$

2. The number of days in January through August plus 13 because RD was born on the 13th of September

$$31 + 29 + 31 + 30 + 31 + 30 + 31 + 31 + 13 = 257 \text{ days}$$

3. Add the numbers from the previous steps

$$39,081.75 + 257 = 39,338.75 \text{ days}$$

4. Divide by 4

$$107 \div 4 = 26.75$$

5. Round down 26.5 → 26 leap years

6. Subtract the number of leap years from the number of years since RD's birth.

$$107 - 26 = 81 \text{ regular years}$$

7. Plug the values into the equation 365x+366y

$$365x + 366y$$
$$x = 81$$
$$y = 26$$
$$365(81) + 366(26) = 39,081$$

There have been 39,081 days since RD was born

8. Divide by 7 and take the remainder

$$39081 \div 7 = 5583\ R0$$

9. The remainder was 0, which means that RD would have been born on a Monday, which is false. He was born on a Wednesday, so this method fails.

This method didn’t incorporate the days of the month into the answer, so it failed.

**Solution:**

1. Find the difference between the current year minus 1 year and the birth year of the birthday.
2. Divide that difference by 4, then take the number you get and remove the decimal without rounding, this is the number of leap years (y) for step 6.
3. Subtract the number you got in step 2 from the number you got in step 1, this is the number of regular years (x) for step 6.
4. Find the number of days before your birthday in the year you were born, using Table 1.
5. Determine if your birth year is a leap year (leap years happen on years that are divisible by 4, so to determine if your birth year is a leap year, divide it by 4. If there is no remainder, then your birth year is a leap year
6. Subtract what you got from step 4 from the total number of days in your birth year. (If your birthday **is** on a leap year then the total number of days would be 366. If your birthday is **not** a leap year then the total number of days would be 365.)
7. Use the equation 365x+366y+z to get the number of days since January 1st this year, (x= number of regular years, y= number of leap years z= difference found in step 6).
8. Use the sum that we got in step 7 and divide it by 7 using long division to find a remainder.
9. Use the remainder to count back from Monday to get the day of the week that you were born on. For your luxury, we have done that for you, see Table 2.

Proof of our solution:

We used Marylin Monroe's birthday (June 1st, 1926 which was a Tuesday).

1. Subtract 1 from Marylin Monroe's birth year and the current year.

$$(2024 - 1) - 1926 = 97$$

2. Number of leap years:

$$97 \div 4 = 24.25$$

Truncate (remove the decimals): 24.25→ 24 leap years

3. Number of regular years:

$$97 - 24 = 73$$

4. Find the number of days before June 1st, 1926

   1926 was **not** a leap year, therefore there were only 28 days in February

$$31 + 28 + 31 + 30 + 31 = 151 \text{ days}$$

5. Total number of days in birth year - number of days before birthday (# from step 4)

   1926 was **not** a leap year, therefore there were 365 days in the whole year.

$$365 - 151 = 214$$

6. Input values into 365x + 366y + z

$$365x + 366y + z$$
$$x = 73$$
$$y = 24$$
$$z = 214$$
$$365(73) + 366(24) + 214 = 35,643$$

7. Divide the sum from step 6 by 7 using long division.

$$35643 \div 7 = 5,091\ R6$$

8. Count back 6 days from Monday

   We get Tuesday. Indeed, Marylin Monroe was born Tuesday, therefore our process is correct.

Table 1

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

*29 in leap years

Table 2

| Day of the week | Monday | Tuesday | Wed | Thu | Friday | Sat | Sun |
|---|---|---|---|---|---|---|---|
| Number of days back from Monday | 0 | 6 | 5 | 4 | 3 | 2 | 1 |

Why this works:

The reason why this process works is because we are counting back the number of days from January 1st 2024 to the Monday after the person was born, then we divide by 7 which is the number of days in a week, and whatever is remaining is the number of days back from that Monday.

Extensions:

1. Create a program that performs the mathematical equations for the user to find the day they were born.
   Example Answer using Python:

```python
import math

byear = int(input("Enter the year you were born: "))
bmonth = input("Enter the month you were born (in all lowercase): ")
bday = int(input("Enter the day you were born: "))
this_year = int(input("Enter the current year: "))

year_diff = ((this_year-1) - byear)

y = math.floor(year_diff/4)  # y = number of leap years
x = (year_diff-y)            # x = number of regular years

def isLeapYear(byear):
    if byear%4 == 0:
        return True
    else:
        return False

if isLeapYear(byear) == True:
    months = [31,29,31,30,31,30,31,31,30,31,30,31]
    num_days = 366
else:
    months = [31,28,31,30,31,30,31,31,30,31,30,31]
    num_days = 365

if bmonth == 'january':
    d = bday-1
elif bmonth == 'february':
    d = months[0] + (bday-1)
elif bmonth == 'march':
    d = sum(months[0:2]) + (bday-1)
elif bmonth == 'april':
    d = sum(months[0:3]) + (bday-1)
elif bmonth == 'may':
    d = sum(months[0:4]) + (bday-1)
elif bmonth == 'june':
    d = sum(months[0:5]) + (bday-1)
elif bmonth == 'july':
    d = sum(months[0:6]) + (bday-1)
elif bmonth == 'august':
    d = sum(months[0:7]) + (bday-1)
elif bmonth == 'september':
    d = sum(months[0:8]) + (bday-1)
elif bmonth == 'october':
    d = sum(months[0:9]) + (bday-1)
elif bmonth == 'november':
    d = sum(months[0:10]) + (bday-1)
else:
    d = sum(months[0:11]) + (bday-1)


z = num_days - d

num_days = (365*x + 366*y + z)

if num_days%7 == 0:
    print("You were born on a Monday!")
elif num_days%7 == 1:
    print("You were born on a Sunday!")
elif num_days%7 == 2:
    print("You were born on a Saturday!")
elif num_days%7 == 3:
    print("You were born on a Friday!")
elif num_days%7 == 4:
    print("You were born on a Thursday!")
elif num_days%7 == 5:
    print("You were born on a Wednesday!")
elif num_days%7 == 6:
    print("You were born on a Tuesday!")
else:
    print("Whoops! something went wrong :(")
```

2. How could you find the day of the week for someone with a birthday before the year 1900?
3. Find the day (number) of the month you were born on using your birth year, birth month, and day of the week of your birthday.