Calendar Month Program

MAY 2012

Sun	Mon	Tues	Wed	Thur	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

The Problem

The problem is to display a calendar month for any given month between January 1800 and December 2099. The format of the month should be as shown on the right..

Problem Analysis

Two specific algorithms are needed for this problem. First, we need an algorithm for computing the first day of a given month for years 1800 through 2099. For this, we will use the algorithm discussed in Unit 1. The second needed algorithm is for appropriately displaying the calendar month, given the day of the week that the first day falls on, and the number of days in the month. You will develop this algorithm.

Program Design

Meeting the Program Requirements

You will develop and implement an algorithm that displays the month as given. There is no requirement of how the month and year are to be entered, so let's request the user to enter the month and year as integer values, with appropriate input error checking.

Data Description

What needs to be represented in the program is the month and year entered, whether the year is a leap year or not, the number of days in the month, and which day the first of the month falls on. Given that information, the calendar month can be displayed. The year and month will be entered and stored as integer values, represented by variables `year` and `month`,

```
year = 2012       month = 5
```

The remaining values will be computed by the program based on the given year and month, as given below,

```
leap_year        num_days_in_month       day_of_week
```

Variable `leap_year` holds a Boolean (`True/False`) value. Variables `num_days_in_month` and `day_of_week` each hold integer values.

Algorithmic Approach

First, we need an algorithm for determining the day of the week that a given date falls on. The algorithm for this from Unit 1 is copied below.

To determine the day of the week for a given **month**, **day**, and **year**:

1. Let **century_digits** be equal to the first two digits of the year.
2. Let **year_digits** be equal to the last two digits of the year.
3. Let **value** be equal to **year_digits** + floor(**year_digits** / 4)
4. If **century_digits** equals 18, then add 2 to **value**, else
   if **century_digits** equals 20, then add 6 to **value**.
5. If the **month** is equal to January and the **year** is not a leap year,
   then add 1 to **value**, else,

   if the **month** is equal to February and the **year** is a leap year, then
   add 3 to **value**; if not a leap year, then add 4 to **value,** else,

   if the **month** is equal to March or November, then add 4 to **value**, else,

   if the **month** is equal to April or July, then add 0 to **value**, else,

   if the **month** is equal to May, then add 2 to **value**, else,

   if the **month** is equal to June, then add 5 to **value**, else,

   if the **month** is equal to August, then add 3 to **value**, else,

   if the **month** is equal to October, then add 1 to **value**, else,

   if the **month** is equal to September or December, then add 6 to **value**,
6. Set **value** equal to (**value** + **day**) mod 7.
7. If **value** is equal to 1, then the day of the week is Sunday; else

   if **value** is equal to 2, day of the week is Monday; else

   if **value** is equal to 3, day of the week is Tuesday; else

   if **value** is equal to 4, day of the week is Wednesday; else

   if **value** is equal to 5, day of the week is Thursday; else

   if **value** is equal to 6, day of the week is Friday; else

   if **value** is equal to 0, day of the week is Saturday

You also need to determine how many days are in a given month, which relies on an algorithm for determining leap years for the month of February. The code for this has already been developed in the “Number of Days in Month” program in the last lesson. Please, reuse the portion of code from that program for determining leap years, reproduced below.

```
 if (year % 4 == 0) and (not (year % 100 == 0) or year % 400): leap_year =
 True
else:
   leap_Year = False
```

Let’s review how this algorithm works, and try to determine the day of the week on which May 24, 2025 falls. First, variable `century_digits` (holding the first two digits of the year) is set to `20` and `year_digits` (holding the last two digits of the year) is set to `25` (**steps 1 and 2**). Variable `value`, in **step 3**, is then set to

```
value = year_digits + floor(year_digits / 4)
```

$$= \quad 25 + \text{floor}(25/4) \rightarrow 25 + \text{floor}(6.25) \rightarrow 25 + 6 \rightarrow 31$$

In **step 4**, since `century_digits` is equal to `20`, `value` is incremented by 6,

$$\text{value} = \text{value} + 6 \rightarrow 31 + 6 \rightarrow 37$$

In **step 5**, since the month is equal to May, `value` is incremented by 2,

$$\text{value} = \text{value} + 2 \rightarrow 37 + 2 \rightarrow 39$$

In **step 6**, `value` is updated based on the day of the month. Since we want to determine the day of the week for the 24th (of May), `value` is updated as follows,

$$\begin{aligned} &\text{value} \equiv (\text{value} + \textit{day of the month}) \bmod 7 \\ &= (39 + 24) \bmod 7 \\ &= 63 \bmod 7 \\ &\equiv 0 \end{aligned}$$

Therefore, by **step 7** of the algorithm, the day of the week for May 24, 2025 is a Saturday. A table for the interpretation of the day of the week for the final computed value is shown below:

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

Program Stages

You will develop and test the program in three stages.

Stage 1 - Determining the Number of Days in the Month/Leap Years

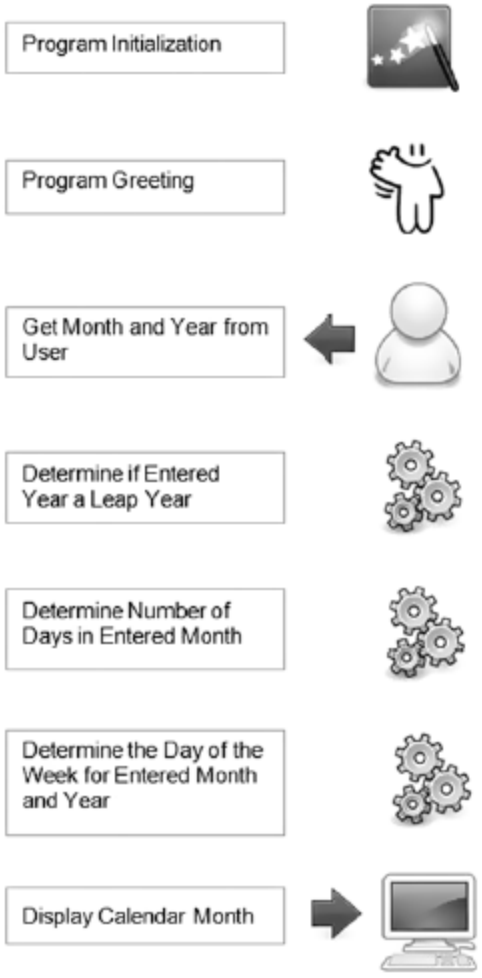
You will develop and test the program in three stages. First, you will implement and test the code that determines, for a given month and year, the number of days in the month and whether the year is a leap year or not.

Stage 2 - Determining the Day of the Week

Next, you will implement and test the code that determines what day of the week is represented by the given month and date.

Stage 3 - Displaying the Calendar Month

Next, you will implement and test the code that determines the correct calendar format represented by the given month and date.



Stage 1 - Determining the Number of Days in the Month/Leap Years

Start a new Python Project and name it Calendar Month. Enter the code below:

```
1  # Calendar Month Program (stage 1)
2
3  # init
4  terminate = False
5
6  # program greeting
7  print('This program will display a calendar month between 1800 and 2099')
8
9  while not terminate:
10     # get month and year
11     month = int(input('Enter month 1-12 (-1 to quit): '))
12
13     if month == -1:
14         terminate = True
15     else:
16         while month < 1 or month > 12:
17             month = int(input('INVALID INPUT - Enter month 1-12: '))
18
19         year = int(input('Enter year (yyyy): '))
20
21         while year < 1800 or year > 2099:
22             year = int(input('INVALID - Enter year (1800-2099): '))
23
24         # determine if leap year
25         if (year % 4 == 0) and (not (year % 100 == 0) or (year % 400 == 0)):
26             leap_year = True
27         else:
28             leap_year = False
29
30         # determine num of days in month
31         if month in (1, 3, 5, 7, 8, 10, 12):
32             num_days_in_month = 31
33         elif month in (4, 6, 9, 11):
34             num_days_in_month = 30
35         elif leap_year:  # February
36             num_days_in_month = 29
37         else:
38             num_days_in_month = 28
39
40         print ('\n', month, ',', year, 'has', num_days_in_month, 'days')
41
42         if leap_year:
43             print (year, 'is a leap year\n')
44         else:
45             print (year, 'is NOT a leap year\n')
```

Notes

The month and year entered by the user are stored in variables `month` and `year`. While loops are used at lines 16 and 21 to perform input error checking. Lines 25–28 are adapted from the previous Number of Days in Month program for determining leap years. Lines 31–38 are similar to the previous program for determining the number of days in a month, stored in variable `num_days_in_month`. Lines 42– 45 contain added code for the purpose of testing. These instructions will not be part of the final program. The program continues to prompt for another

month until 21 is entered. Thus, Boolean flag terminate is initialized to False (line 4) and set to True (line 14) when the program is to terminate.

Stage 1 Testing

Test Stage 1 programming entering the following year and moths, and recording your results in the following table.

See sample test results on the right.

```
Enter month (1-12): 14
INVALID INPUT
Enter month (1-12): 1
Enter year (yyyy): 1800

1 , 1800 has 31 days
1800 is NOT a leap year
```

Calendar Month	Expected Results		Actual Results		Evaluation?
	num days	leap year?	num days	leap year?	
January 1800	31	no	31	no	passed
February 1900	28	no			
February 1984	29	yes			
February 1985	28	no			
February 2000	29	yes			
March 1810	31	no			
April 1912	30	yes			
May 2015	31	no			
June 1825	30	no			
July 1928	31	yes			
August 2031	31	no			
September 1845	30	no			
October 1947	31	no			
November 2053	30	no			
December 2099	31	no			

If all test cases, pass, you can move on to Stage 2.

Stage 2 - Determining the Day of the Week

Enter the code below, that determines what day of the week is represented by the given month and date.

```
# Calendar Month Program (stage 2)

# init
terminate = False

# program greeting
print('This program will display a calendar month between 1800 and 2099'

while not terminate:
    # get month and year
    month = int(input('Enter month (1-12): '))

    if month == -1:
        terminate = True
    else:
        while month < 1 or month > 12:
            month = int(input('INVALID INPUT - Enter month 1-12: '))

        year = int(input('Enter year (yyyy): '))

        while year < 1800 or year > 2099:
            year = int(input('INVALID - Enter year (1800-2099): '))

        # determine if leap year
        if (year % 4 == 0) and (not(year % 100 == 0) or (year % 400 == 0)):
            leap_year = True
        else:
            leap_year = False

        # determine num of days in month
        if month in (1,3,5,7,8,10,12):
            num_days_in_month = 31
        elif month in (4,6,9,11):
            num_days_in_month = 30
        elif leap_year:  # February
            num_days_in_month = 29
        else:
            num_days_in_month = 28

        # determine day of the week
        century_digits = year // 100
        year_digits = year % 100

        value = year_digits + (year_digits // 4)

        if century_digits == 18:
            value = value + 2
        elif century_digits == 20:
            value = value + 6

```

(Continued on next page)

Stage 2 code, continued from previous page:

```
51          if month == 1 and not leap_year:
52              value = value + 1
53          elif month == 2:
54              if leap_year:
55                  value = value + 3
56              else:
57                  value = value + 4
58          elif month == 3 or month == 11:
59              value = value + 4
60          elif month == 5:
61              value = value + 2
62          elif month == 6:
63              value = value + 5
64          elif month == 8:
65              value = value + 3
66          elif month == 9 or month == 12:
67              value = value + 6
68          elif month == 10:
69              value = value + 1
70
71          day_of_week = (value + 1) % 7  # 1-Sunday, 2-Monday, ...,
72
73          # display results
74          print('Day of the week is', day_of_week)
```

Notes:

For testing purposes, there is no need to convert the day number into the actual name (e.g., “Monday”)—this “raw output” is good enough. Also, for this program, we will need to determine only the day of the week for the first day of any given month, since all remaining days follow sequentially. Therefore the day value in the day of the week algorithm is hard-coded to 1 (line 1)

The algorithm operates separately on the first two digits and the last two digits of the year. On line 41, integer division is used to extract the first two digits of the year (for example `1860 // 100` equals 18).

On line 42, the **modulus** operator, %, is used to extract the last two digits in the given year (for example `1860 % 100` equals 60)

Stage 2 Testing

Test Stage 2 programming entering the following year and months, and recording your results. See sample test results below:

```
1
Enter month (1-12): 4
Enter year (yyyy): 1860
Day of the week is 1
Enter month (1-12): -1
>>>
```

Test your results of the Stage 2 program, using the dates in the Stage 1 Test table. If all the dates pass, incremental save _stage2, and continue on to Stage 3.

Stage 3 - Displaying the Calendar Month

Delete the code from lines 73-74. Then add the following, to complete Stage 3.

```
73          # determine month name
74          if month == 1:
75              month_name = 'January'
76          elif month == 2:
77              month_name = 'February'
78          elif month == 3:
79              month_name = 'March'
80          elif month == 4:
81              month_name = 'April'
82          elif month == 5:
83              month_name = 'May'
84          elif month == 6:
85              month_name = 'June'
86          elif month == 7:
87              month_name = 'July'
88          elif month == 8:
89              month_name = 'August'
90          elif month == 9:
91              month_name = 'September'
92          elif month == 10:
93              month_name = 'October'
94          elif month == 11:
95              month_name = 'November'
96          else:
97              month_name = 'December'
98
99          # display month and year heading
100         print('\n', ' ' + month_name, year)
101
102         # display rows of dates
103         if day_of_week == 0:
104             starting_col = 7
105         else:
106             starting_col = day_of_week
107
108         current_col = 1
109         column_width = 4
110         blank_char = ' '
111         blank_column = format(blank_char, str(column_width))
112
113         while current_col <= starting_col:
114             print(blank_column, end='')
115             current_col = current_col + 1
116
117         current_day = 1
118
119         while current_day <= num_days_in_month:
120             if current_day < 10:
121                 print (format(blank_char, '3') + str(current_day), end='')
122             else:
123                 print (format(blank_char, '2') + str(current_day), end='')
124
125             if current_col <= 7:
126                 current_col = current_col + 1
127             else:
128                 current_col = 1
129                 print()
130
131             current_day = current_day + 1
132
133         print('\n')
```

Notes:
The corresponding name for the month number is determined on **lines 74–97** and displayed (**line 100**). The while loop at **line 113** moves the cursor to the proper starting column by "printing" the `column_width` number of blank characters (4) for each column to be skipped.

The while loop at **line 119** displays the dates. Single-digit dates are output (**line 121**) with three leading spaces, and two-digit dates with two (**line 123**) so that the columns line up. Each uses the **newline suppression form of print**, `print(..., end5'')` to prevent the cursor from moving to the next screen line until it is time to do so.

Variable `current_day` is incremented from `1` to the number of days in the month. Variable `current_col` is also incremented by `1` to keep track of what column the current date is being displayed in. When `current_col` equals 7, it is rest to 1 (line 128) and `print( )`moves the cursor to the start of the next line (line 129). Otherwise, `current_col` is simply incremented by 1.

Stage 3 Testing

Test Stage 3 programming by entering the first year and month (January 1800. You should see the following:

```
This program will display a calendar month between 1800 and 2099

Enter month 1-12 (-1 to quit): 1
Enter year (yyyy): 1800

  January   1800
                    1   2   3   4
   5   6   7   8   9  10  11  12
  13  14  15  16  17  18  19  20
  21  22  23  24  25  26  27  28
  29  30  31

Enter month (1-12): -1
>>>
```

Test one more month date, to confirm the results.

Something is obviously wrong. The calendar month is displayed with eight columns instead of seven. The testing of all other months produces the same results. Since the first two stages of the program were successfully tested, the problem must be in the code added in the final stage. The code at **line 74** simply assigns the month name. Therefore, we reflect on the logic of the code starting on **line 103**.

Lines 128–129 is where the column is reset back to column 1 and a new screen line is started, based on the current value of variable current_col,

```
if current_col ,5 7:
   current_col 5 current_col 1 1
else:
```

```
current_col 5 1
print()
```

Variable `current_col` is initialized to 1 at line 108, and is advanced to the proper starting column on lines 113–115. Variable `starting_col` is set to the value (`0-6`) for the day of the week for the particular month being displayed. Since the day of the week results have been successfully tested, we can assume that `current_col` will have a value between 0 and 6. With that assumption, you can step through lines 125–129 and see if this is where the problem is. Stepping through a program on paper by tracking the values of variables is referred to as **deskchecking**. Check what happens as the value of `current_col` approaches 7, as shown below:

Current value of **current_col**	Value of condition **current_col <= 7**	Updated value of **current_col**
5	True	6
6	True	7
7	True	8
8	False	1
1	True	2
etc.		

Now it is clear what the problem is - the classic *"off by one" error*! The condition of the while loop should be `current_col , 7`, *not* `current_col ,5 7`. `Current_col` should be reset to 1 once the seventh column has been displayed (when `current_col` is 7). Using the ,5 operator causes `current_col` to be reset to 1 only after an *eighth* column is displayed. Thus, we make this correction in the program,

```
if current_col < 7:
current_col = current_col 1 1 else:
current_col = 1
print()
```

After re-executing the program with this correction we get the correct column format, as seen below:

```
This program will display a calendar month between 1800 and 2099

Enter month 1-12 (-1 to quit): 1
Enter year (yyyy): 1800

  January   1800
                    1   2   3
   4   5   6   7   8   9  10
  11  12  13  14  15  16  17
  18  19  20  21  22  23  24
  25  26  27  28  29  30  31

Enter month (1-12): -1
>>>
```

Although the column error has been corrected, notice that the first of the month appears under the wrong column—the month should start on a Wednesday (fourth column), not a Thursday column (fifth column). The problem must be in how the first row of the month is displayed. Other months are tested, each found to be off by one day. We therefore look at **lines 113–115** that are responsible for moving over the cursor to the correct starting column,

```
while current_col <= starting_col:
print(blank_column, end='')
current_col = current_col + 1
```

We consider whether there is another “off by one” error. Reconsidering the condition of the while loop, we realize that, in fact, this is the error. If the correct starting column is 4 (Wednesday), then the cursor should move past three columns and place a 1 in the fourth column. The current condition, however, would move the cursor past *four* columns, thus placing a 1 in the fifth column (Thursday). The corrected code is given below.

```
while current_col < starting_col:
print(' ', end='')
current_col = current_col + 1
```

The month is now correctly displayed.

Final Testing

Complete the testing by executing the program on a set of test cases. Although the test plan is not as complete as it could be, it includes test cases for months from each century, including both leap years and non-leap years.

Calendar Month	Expected Results		Actual Results		Evaluation?
	First Day	num days	First Day	num days	
April 1912	Sunday	30			
February 1985	Monday	28			
May 2015	Tuesday	31			
January 1800	Wednesday	31			
February 1900	Thursday	28			
August 2031	Friday	29			
January 2011	Saturday	31			