# Assignment 2: Lunar New Year

Due: 20:00, Tue 2 Oct 2019          File name: `lny.cpp`          Full marks: 100

## Introduction

The objective of this assignment is to learn how to use variables, operators, expressions, and console input/output. You will write a program to *estimate* the date of Lunar New Year (LNY / Chinese New Year / Spring Festival).

No, it is not LNY yet! It usually appears between 21 Jan and 21 Feb. Determining the exact LNY date involves complex astronomical calculation. But LNY is always on a new moon, which repeats every 29.53 days on average. If we know a specific moment where the moon was new (e.g., HKT 02:13, 6 Jan 2000), then every 29.53 days later, the moon will be new again. We use this idea to find the first new moon on or after HKT 0:00, 21 Jan of a year to estimate the LNY date. Accuracy is ±1 day in general (although there can be huge error in rare cases).

Let $y$ be the year which we want to estimate the LNY date, $m = 1$, and $d = 21$ (meaning 21 Jan). Then we compute an integer $n$, which means the number of days until the next new moon on or after 21 Jan, as follows:

$$
\begin{aligned}
a &= \left\lfloor \frac{14 - m}{12} \right\rfloor \\
b &= m + 12a - 3 \\
c &= y + 4800 - a \\
j &= d + \left\lfloor \frac{153b + 2}{5} \right\rfloor + 365c + \left\lfloor \frac{c}{4} \right\rfloor - \left\lfloor \frac{c}{100} \right\rfloor + \left\lfloor \frac{c}{400} \right\rfloor - 32045 \\
k &= \frac{j - 2451551.0923611}{29.530587981} \\
n &= \lfloor 29.530587981 \times (\lceil k \rceil - k) \rfloor
\end{aligned}
$$

In the above formulae, $y, m, d, a, b, c, j, n$ are <u>integers</u>, while $k$ is a <u>real number</u>. Note that $\lfloor x \rfloor$ and $\lceil x \rceil$ mean the *floor* and *ceiling* of $x$ respectively. That is, floor is the nearest integer not greater than $x$, and ceiling is the nearest integer not smaller than $x$. E.g., $\lfloor 2.8 \rfloor = \lfloor 2 \rfloor = 2$ and $\lceil 0.3 \rceil = \lceil 1 \rceil = 1$.

Furthermore, the day of the week (Mon–Sun) of the estimated date can be determined using $((j + n) \bmod 7) + 1$, where mod is the modulo operation. The result is 1–7, meaning Mon–Sun respectively. The following shows two computation examples.

**Example 1:** $y = 2019$

$$
\begin{aligned}
a &= \left\lfloor \frac{14 - 1}{12} \right\rfloor = 1 \\
b &= 1 + 12 \times 1 - 3 = 10 \\
c &= 2019 + 4800 - 1 = 6818 \\
j &= 21 + \left\lfloor \frac{153 \times 10 + 2}{5} \right\rfloor + 365 \times 6818 + \left\lfloor \frac{6818}{4} \right\rfloor - \left\lfloor \frac{6818}{100} \right\rfloor + \left\lfloor \frac{6818}{400} \right\rfloor - 32045 \\
&= 21 + 306 + 2488570 + 1704 - 68 + 17 - 32045 = 2458505
\end{aligned}
$$

$$k = \frac{2458505 - 2451551.0923611}{29.530587981} = \frac{6953.9076389}{29.530587981} = 235.481516432187$$
$$n = \lfloor 29.530587981 \times (236 - 235.481516432187) \rfloor = \lfloor 15.3111246160182 \rfloor = 15$$

Therefore, LNY of year 2019 is around 15 days after 21 Jan. That is, 5 Feb. Also, $((j + n) \bmod 7) + 1 = ((2458505 + 15) \bmod 7) + 1 = (2458520 \bmod 7) + 1 = 1 + 1 = 2$. So, 5 Feb 2019 is Tuesday.

**Example 2:** $y = 2061$

$$a = \left\lfloor \frac{14 - 1}{12} \right\rfloor = 1$$
$$b = 1 + 12 \times 1 - 3 = 10$$
$$c = 2061 + 4800 - 1 = 6860$$
$$j = 21 + \left\lfloor \frac{153 \times 10 + 2}{5} \right\rfloor + 365 \times 6860 + \left\lfloor \frac{6860}{4} \right\rfloor - \left\lfloor \frac{6860}{100} \right\rfloor + \left\lfloor \frac{6860}{400} \right\rfloor - 32045$$
$$= 21 + 306 + 2503900 + 1715 - 68 + 17 - 32045 = 2473846$$
$$k = \frac{2473846 - 2451551.0923611}{29.530587981} = \frac{22294.9076389}{29.530587981} = 754.976760139167$$
$$n = \lfloor 29.530587981 \times (755 - 754.976760139167) \rfloor = \lfloor 0.68628675501781 \rfloor = 0$$

Therefore, LNY of year 2061 is around 0 day after 21 Jan. That is, 21 Jan. Also, $((j + n) \bmod 7) + 1 = ((2473846 + 0) \bmod 7) + 1 = 4 + 1 = 5$. So, 21 Jan 2061 is Friday.

## Program Specification

The program should obtain a year as user input. You can assume _the user input is always an integer that is at least 2000_ (because we use HKT 02:13, 6 Jan 2000 as the reference new moon). You do not have to check if the input is out of this assumption. Then apply the above method to estimate the LNY date of the input. The date should be printed in the format "_ddd, d mmm y_", where _ddd_ is the three-letter abbreviation for day of the week (e.g., Tue), _d_ is the day of the month, _mmm_ is the three-letter abbreviation for month (e.g., Feb), and _y_ is the year.

### Remarks

- Use <u>int</u> variables for $a, b, c, j, n$ and <u>double</u> variable for $k$.
- In the formulae of $a$ and $j$, the floor operations $\lfloor \frac{\cdots}{\cdots} \rfloor$ are simply _integer divisions_.
- In the formula of $n$, the floor operation can be written as <u>int(…)</u>, and the ceiling operation can be written as <u>ceil(…)</u>. You have to add <u>#include <cmath></u> at the beginning of your program.

## Sample Run

In the following sample runs, the blue text is user input and the other text is the program printout. You can try the provided sample program for other input. _Your program output should be exactly the same as the sample program_ (same text, symbols, letter case, spacings, etc.). Note that _there is a space after the ':' in the program printout_.

```
Enter a year: 2019↵
LNY of 2019 is around: Tue, 5 Feb 2019
```

```
Enter a year: 2061↵
LNY of 2061 is around: Fri, 21 Jan 2061
```

```
Enter a year: 54321↵
LNY of 54321 is around: Wed, 16 Feb 54321
```

## Submission and Marking

- Your program file name should be <u>lny.cpp</u>. Submit the file in Blackboard (<u>https://blackboard.cuhk.edu.hk/</u>).
- Insert *your name*, *student ID*, and *e-mail* as comments at the beginning of your source file.
- You can submit your assignment multiple times. Only the latest submission counts.
- Your program should be *free of compilation errors and warnings*.
- Your program should *include suitable comments as documentation*.
- ***Do NOT plagiarize.*** Sending your work to others is subjected to the same penalty as the copier.