CS 210 - Fundamentals of Programming I
Spring 2019 - Programming Project 1
20 points

Out: January 22, 2019
Due: January 29, 2019 (Tuesday)

Reminder: This is a programming project, and work on this assignment should be done individually. Assistance from other students is limited to questions about specific issues as noted in the syllabus.

Problem Statement

For a weather application, we would like to determine the phase of the moon given a date and time in hours. For this program, the phase of the moon will be given in degrees. A phase of 360° is a full moon. It reduces to 180° at the new moon. And finally, goes to 0° at the next full moon. The data we need is as follows:

Data	Description
year	Year of the date (e.g. 2016)
month	Month of the date (1 is January, 2 is February, etc.)
day	Day of the month
hour	Hour of the day in 24-hour notation (i.e. 0 to 23).
timezone	The local timezone as an offset from UTC (e.g., CST is -6)

The following equations for calculating the phase of the moon were developed by Belgian astronomer Jean Meeus in his book *Astronomical Algorithms*. Understanding why these equations work is left as an exercise for the reader.

1. *jd* is the date converted into a Julian date at UTC. The vertical bars have small bars on the bottom and are floor function brackets (i. e., the largest integer smaller than the quantity).

$$jd = 367\ year - \left\lfloor \frac{7 \left(year + \left\lfloor \frac{month+9}{12.0} \right\rfloor \right)}{4.0} \right\rfloor + \left\lfloor \frac{275\ month}{9.0} \right\rfloor + day + \frac{hour - timezone}{24.0} + 1721013.5$$

2. *t* is the proportion of the Julian century

$$t = \frac{jd - 2451545.0}{36525.0}$$

3. *el* is the moon's mean elongation in degrees, the angle between the sun and the moon with Earth as the reference point

$$el = 297.8501921 + 445267.1114034\, t - 0.0018819\, t^2 + \frac{t^3}{545868.0} - \frac{t^4}{113065000.0}$$

4. *ma* is the moon's mean anomaly in degrees, the angular distance from the pericenter of the moon's elliptical orbit which a fictitious moon would have if it moved in a circular orbit, with constant speed, in the same orbital period as the actual moon in its elliptical orbit.

$$ma = 134.9633964 + 477198.8675055\, t - 0.0087414\, t^2 + \frac{t^3}{69699.0} - \frac{t^4}{14712000.0}$$

5. *sa* is the sun's mean anomaly in degrees

$$sa = 357.5291092 + 35999.0502909\, t - 0.0001536\, t^2 + \frac{t^3}{24490000.0}$$

6. *pa* is the phase angle of the moon in degrees. However, the trigonometric library functions in C require their arguments to be in radians (rather than degrees). The formula for converting degrees to radians is

$$radians = degrees \times \frac{\pi}{180}$$

and is used to convert the various angles into radians as follows

$$pa = 180.0 - el - 6.289 \sin\left(ma\,\frac{\pi}{180.0}\right) + 2.1\sin\left(sa\,\frac{\pi}{180.0}\right) - 1.274\sin\left((2\,el - ma)\,\frac{\pi}{180.0}\right)$$
$$- 0.658\sin\left(2\,el\,\frac{\pi}{180.0}\right) - 0.214\sin\left(2\,ma\,\frac{\pi}{180.0}\right) - 0.11\sin\left(el\,\frac{\pi}{180.0}\right)$$

7. Finally, to normalize the phase angle into the range [0..360] degrees

$$pa = pa - \left\lfloor \frac{pa}{360.0} \right\rfloor \times 360.0$$

Assignment
Write a C program that computes the phase of the moon angle for a date and time. It should ask the user for a year, a month, a day of year, the hour of the day, and a timezone offset, and then display the phase of the moon angle for that date and time.

The output of the program must conform exactly to the example runs shown. Note there is a blank line between the program heading and the first input prompt and a blank line between the last input line and the first line of results output. And as usual, there must be a newline after the last line of output.

Coding Notes
- Use 3.1415926 for the value of π.
- The transcendental functions (sin, cos, etc.) and the floor function are in the **<math.h>** library.
- Note that the phase angle is a real number, but that you do not want to print out anything after the decimal point.
- Do not submit your project until you get the same results as the example runs.
- If you're having trouble computing the correct answers, try printing out the intermediate values to help you debug your program. E.g., here are the intermediate values for the first example above using format specifier **%g**:

```
Julian date: 2.45757e+06
Proportion of Julian century: 0.165064
Moon mean elongation: 73795.4
Moon mean anomaly: 78903.3
Sun mean anomaly: 6299.67
Phase of moon (before normalization): -73619.8
```

Be sure to comment out (or remove) any such debugging statements before you submit your program.

REMINDER: Your program must compile for it to be graded. Submissions that do not compile will be returned for resubmission and assessed a late penalty. Submissions that do not substantially work also will be returned for resubmission and assessed a late penalty.

Follow the program documentation guidelines in the *C Programming Style Guideline* handout. As stated in the syllabus, part of the grade on a programming assignment depends on how well you adhere to the guidelines. The grader will look at your code and grade it according to the guidelines.

What to Submit
Electronically submit a zipfile containing **main.c** (only) as explained in class and in the handout *Submission Instructions for CS 210*. The submission system will start accepting assignments the evening of Wednesday, January 23. Reminders: you may submit as many times as needed, and only the last submission will be graded. All programming projects are due by 11:59pm.

Example Runs (there are three separate runs; user input shown in **bold**)

```
PHASE OF THE MOON
This program will calculate the phase of the moon for any date
and time in hours. Full moon is 360 degrees, reducing to 180 degrees
at new moon, and back to full moon at 0 degrees.

Enter year: 2016
Enter month (1-12): 7
Enter day: 4
Enter hour in 24-hour format: 6
Enter timezone: -5

Phase of the moon is 180 degrees.
```

```
PHASE OF THE MOON
This program will calculate the phase of the moon for any date
and time in hours. Full moon is 360 degrees, reducing to 180 degrees
at new moon, and back to full moon at 0 degrees.

Enter year: 2016
Enter month (1-12): 1
Enter day: 1
Enter hour in 24-hour format: 6
Enter timezone: -6

Phase of the moon is 278 degrees.


PHASE OF THE MOON
This program will calculate the phase of the moon for any date
and time in hours. Full moon is 360 degrees, reducing to 180 degrees
at new moon, and back to full moon at 0 degrees.

Enter year: 2010
Enter month (1-12): 8
Enter day: 24
Enter hour in 24-hour format: 11
Enter timezone: -6

Phase of the moon is 360 degrees.
```