Programming Lab 9C
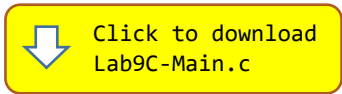
Movements of the Sun and the Moon

Topics: Floating-point arithmetic

Prerequisite Reading: Chapters 1-9

Revised: May 27, 2021

Background: The time of sunrise is usually defined as the moment the top of the sun's disc first breaks the plane of the horizon in the morning, and sunset when the top of the sun's disc sinks below the horizon in the evening. The timing varies throughout the year and is also affected by the viewer's longitude, latitude, altitude, and time zone. These changes are driven by the axial tilt and daily rotation of the Earth, its movement in its annual elliptical orbit around the Sun, and the Earth and Moon's paired revolutions around each other.

The Moon, like the Earth, is a sphere, and is always half-illuminated by the Sun. As the Moon travels around the Earth about once every 29½ days, we see more or less of its illuminated half. The Moon's appearance cycles through eight "phases", comprised of four *primary phases* (distinct one-day events in the cycle), and four *intermediate phases* (the days between the primary phases):

New Moon:	Day 1 of the cycle when our side of the Moon is turned away from the Sun and almost completely dark.
First Quarter:	The day the cycle is 25% complete and our side of the Moon is 50% illuminated.
Full Moon:	The day when our side of the Moon is turned towards the Sun and completely illuminated.
Third Quarter:	The day the cycle is 75% complete and our side of the Moon is 50% illuminated.
Waxing Crescent:	The days between the New Moon and First Quarter.
Waxing Gibbous:	The days between the First Quarter and Full Moon.
Waning Gibbous:	The days between the Full Moon and Third Quarter.
Waning Crescent:	The days between the Third Quarter and the next New Moon.

Calculating the time of sunrise or sunset or the dates of the phases of the moon requires a lot of the kind of math that only an astronomer would love. Fortunately, public domain code for accurate sunrise and sunset times and for computing the dates of phases of the moon is available on the web[1,2] and has been adapted for use in this lab.
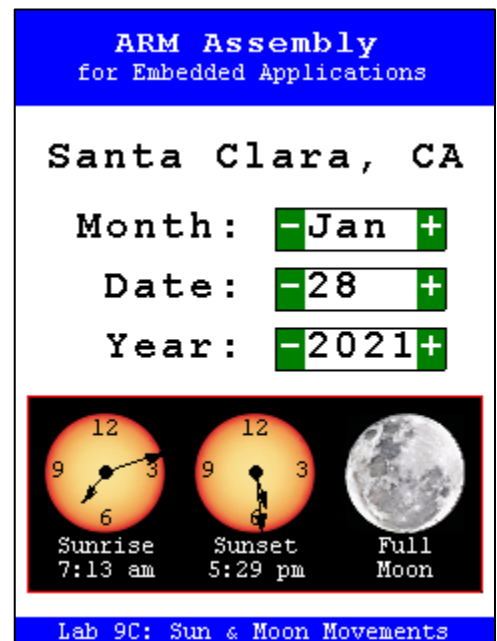
Assignment: The main program will compile and run without writing any assembly. However, your task is to create equivalent replacements in assembly language for the following two functions found in the C main program:

```
float EccentricAnomaly(float e, float M) ;
float Kepler(float m, float ecc) ;
```

The original C versions of these functions have been defined as "weak" so that the linker will automatically replace them in the executable image by those you create in assembly; you do not need to remove the C versions. Your assembly versions must call four other C functions provided in the main program: Deg2Rad, Rad2Deg, sinDeg, and cosDeg. Your code will likely need to push and pop registers; be sure that the total number of registers you push and pop is even so that the address held in the stack pointer remains a multiple of eight to satisfy the data alignment requirements of compiled C code. The call to the library function fabsf in function Kepler may be replaced by a single VABS.F32 instruction.

Test your code with the main program. If your assembly code is correct, the display should look like the image shown and the results should be comparable to similar information found on the web here. The + and − buttons may be used to select a particular date; pressing the blue pushbutton advances to the next date and repeats rapidly if kept depressed.

The program may be modified to provide information for a different city. To do so, find and edit the following five global variables near the beginning of the C main program: location, longitude, latitude, gmtOffset, and obeysDST.

[1] http://stjarnhimlen.se/comp/sunriset.c
[2] http://www.fourmilab.ch/moontoolw/