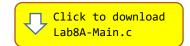*Programming Lab 8A*

Zeller's Rule

Topics: Replacing division by reciprocal multiplication, replacing multiplication by a sequence of addition, subtraction and shift instructions.

Prerequisite Reading: Chapters 1-8
Revised: January 21, 2021

Background[1]: The following formula is named Zeller's Rule and may be used to convert a date into a day of the week.

$$f = k + \frac{13m - 1}{5} + D + \frac{D}{4} + \frac{C}{4} - 2C$$

Where:

k is the day of the month.

m is the month number. Months must be counted differently for Zeller's Rule: March is 1, April is 2, and so on to February, which is 12. (This makes the formula simpler, because on leap years February 29 is counted as the last day of the year.) Thus, January and February are always counted as the 11th and 12th months of the ___previous___ year.

D is the last two digits of the year.

C is the century - the first two digits of the year.

Example: January 29, 2064

$$f = 29 + \frac{13 \times 11 - 1}{5} + 63 + \frac{63}{4} + \frac{20}{4} - 2 \times 20$$
$$= 29 + 28 + 63 + 15 + 5 - 40 = 100$$

ARM Assembly
for Embedded Applications

Month: −Dec +
Date: −26 +
Year: −2020+

Saturday

Zeller1: 24 cyc (Uses Div & Mul)
Zeller2: 21 cyc (No Divide)
Zeller3: 25 cyc (No Multiply)

Lab 8A: Zeller's Rule

Note: $D = 63$ even though the year is 2064 because the month is January (see above). All the divisions above are *unsigned* integer divisions that discard any fractional part. We then use *signed* integer division to get the remainder of f divided by 7 since f can be negative. If the remainder is negative, add 7. (This result is what your assembly language functions must return.) A result of 0 means Sunday, 1 means Monday, etc. For our example, $100/7 = 14$, remainder 2, so January 29, 2064 falls on a Tuesday.

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 three functions found in the C main program. The original C versions 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. This allows you to create and test your assembly language functions one at a time. All three functions share a common set of parameters and return value. However, `Zeller2` may not contain any divide instructions (`SDIV` or `UDIV`) and `Zeller3` may not contain any multiply instructions (`MUL`, `MLS`, etc.):

```
uint32_t Zeller1(uint32_t k, uint32_t m, uint32_t D, uint32_t C) ;
uint32_t Zeller2(uint32_t k, uint32_t m, uint32_t D, uint32_t C) ;
uint32_t Zeller3(uint32_t k, uint32_t m, uint32_t D, uint32_t C) ;
```

Use this webpage to find instruction sequences that will divide by a constant without using a divide instruction. Test your code with the main program. If your code is correct, the display should look like the image shown above. Use the touchscreen to adjust the date and see the corresponding day of the week. Errors will be displayed as white text on a red background.

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[1] Adapted from http://mathforum.org/dr.math/faq/faq.calendar.html