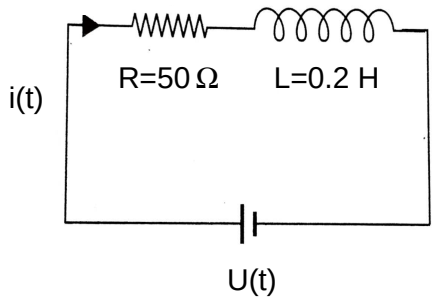
A Series RL Circuit II (continuation of WS 18)

5 April 2023
Worksheet 19

In this worksheet, we will solve a 1^{st} order differential equation using FUNCTION and SUBROUTINE sub-program. The use of the INTENT descriptor and the logical IF construct will be practiced.

A series RL circuit with $R = 50\ \Omega$ and $L = 0.2$ H has a sinusoidal voltage source applied, as shown in the figure below.



The sinusoidal voltage is given by

$$U(t) = \begin{cases} U_0 \sin(\omega t) & \text{if } \ t \le \frac{1}{2}\, T_{\text{final}}\,, \\ \\ \frac{2}{3}\, U_0 \sin(2\omega t) & \text{if } \ t > \frac{1}{2}\, T_{\text{final}}\,, \end{cases} \tag{1}$$

where $U_0 = 150$ V, $\omega = 500\ \text{s}^{-1}$, and $T_{\text{final}} = 10\pi/\omega$. The current $i(t)$ is determined by the differential equation

$$50\, i(t) + 0.2\, \frac{di(t)}{dt} = U(t)\,, \tag{2}$$

where t is the time in seconds. The initial condition for the current is $i(0) = 0$.

Task

Write a structured Fortran program which solves Eq. (2) for times $0 < t \le T_{\text{final}}$. Use a temporal step size of $dt = 0.00001$ seconds. The results for $i(t)$ are to be shown graphically.

Code Design

- Include a short preamble at the beginning of your program.
- There is not keyboard input.
- The global structure of your Fortran code must be a follows:

```
program main
  implicit none
  real :: ....

! Assign numerical values to various physical quantities
  CALL INPUT(dt,R,L,U_0,omega,T_final,t_initial,i_initial)
```

```
! Solve differential equation (2)
  CALL DiffEqSolver(t_initial,T_final,i_initial,omega,dt)

! Write values of various physical quantities to screen
  CALL DATA(dt,R,L,U_0,omega,T_final,t_initial)
end program main

!-------------------------------------------------------------------------

SUBROUTINE INPUT(dt,R,L,U_0,omega,T_final,t_initial,i_initial)

 [ code ]

END SUBROUTINE INPUT

!-------------------------------------------------------------------------

SUBROUTINE DiffEqSolver(t_initial,T_final,i_initial,omega,dt)

 [ code ]

END SUBROUTINE DiffEqSolver

!-------------------------------------------------------------------------

FUNCTION F(t,i,omega,T_half)
! Compute U(t) of Eq. (1)

 [ code ]

END FUNCTION F

!-------------------------------------------------------------------------

SUBROUTINE DATA(dt,R,L,U_0,omega,T_final,t_initial)
  IMPLICIT NONE
  REAL, intent(in) :: dt,R,L,U_0,omega,T_final,t_initial
    WRITE(*,100) dt,R,L,U_0,omega,T_final,t_initial
100 FORMAT(/, ' dt=', F7.5, /, ' R=', F4.1, /, ' L=', F3.1, /, ' U_0=', &
         F5.1, /, ' omega=', F5.1, /, ' T_final=', F5.3, /, ' t_initial=', &
         F3.1, /)
END SUBROUTINE DATA
```

- Graphically compare the results for $i(t)$ $(0 < t \leq T_{\text{final}})$ with those from Worksheet 18.

Submission Instructions: Create a gzipped archive named `ws19.tgz` which contains your Fortran source code and the `pdf` file of your plot. Email the archive to `ewhart317@gmail.com`. Put `PHYS 317 WS 19` in the subject line.