

The purpose of this worksheet is to explore a Fortran code which computes the values of a mathematical function,  $f(x)$ , and its associated Taylor expansion,  $t(x)$ , for given  $x$  values. The numerical values of  $x$  are keyboard input.

Given is the mathematical expression

$$f(x) = \left( x \sqrt{|x|} e^{-x^2 \sin(x^2)} e^{-\sqrt{|x|} \cos(x)} \right) (0.5x + 0.2x^2 + 0.1x^4)^{-1}$$

where  $x \in [-1, 1]$ . The Taylor expansion of this function is given by

$$t(x) = e^{(-0.540302 - 0.841471(1+x)) \sqrt{|x|}} (2.15538 + 0.568043(1+x)) \sqrt{|x|}.$$

The Fortran program which computes  $f(x)$  and  $t(x)$  for a given  $x$  value is shown below:

```
PROGRAM evalMathExpression
```

```
! Purpose: This program computes f(x), t(x), and |f(x)-t(x)| and writes the
! results to standard output for a given value of x. The value of x is
! terminal input.
!
! History:
!   Version      Programmer      Date      Description/Comments
!   -----      -
!       1         Your Name      01/25/2023  Code created from scratch
!
! INPUT:
!   Quantity      Units      Description
!   -----      -
!       x          none      Keyboard input
!
! OUTPUT:
!   Quantity      Units      Description
!   -----      -
!       f          none      function f(x)
!       t          none      function t(x)
!
! SPECIAL REQUIREMENTS: none

      IMPLICIT none
      REAL :: x, f_x, t_x, term1, term2, term3, term4, a, b, c, d, delx

! Input x value from standard input (keyboard)
PRINT *, "Input value for x:"
READ *, x

      term1 = x * SQRT(ABS(x))
      term2 = EXP(- x**2 * SIN(x**2))
      term3 = EXP(- SQRT(ABS(x)) * COS(x))
      term4 = 0.5*x + 0.2*x**2 + 0.1*x**4
```

```

! Compute function f(x)
  f_x = term1 * term2 * term3 / term4

! Assign numerical values to a, b, c, and d used to compute t(x)
  a = 0.540302; b = 0.841471; c = 2.15538; d = 0.568043

! Compute Taylor expansion t(x)
  t_x = EXP( (-a - b*(1.0+x)) * SQRT(ABS(x)) ) * (c + d*(1.0+x)) * SQRT(ABS(x))

! Write results to standard output (terminal)
  PRINT *, f_x, t_x, ABS(f_x - t_x), x

      STOP 'Regular stop encountered'
END PROGRAM evalMathExpression

```

## Tasks

1. Use `mkdir` to create a sub-directory named `worksheet2` on your machine. Use `cd` to change to that directory and use the `touch` command to create an empty file named `evalMathExpression.f90`.
2. Open `evalMathExpression.f90` with a text editor of your choice (e.g. `vim`, `MacVim`, `Emacs`, `gedit`) and enter the Fortran program line by line into this file. Pay special attention to the position of parentheses, quotation marks, commas, and colons.
3. If you are done editing, save the file and compile the program in a terminal by typing

```
gfortran -o evalMathExpression.o evalMathExpression.f90
```

at the shell prompt of the terminal. Type `ls -alF` to check whether or not the binary (executable) file `evalMathExpression.o` has been created in the directory `worksheet2`. The binary file is created only if there are no syntax errors in the source code. If errors occur, try to correct them and recompile the code until the Fortran compiler generates the binary version of the code.

4. To run the program, type

```
./evalMathExpression.o
```

at the shell prompt and hit the return button. You will be prompted to input a value for  $x$ .

For a given  $x$  value, the code computes  $f(x)$ ,  $t(x)$ ,  $\Delta(x) \equiv |f(x) - t(x)|$  and writes the results to standard output (i.e., to the screen/terminal).

5. Run the code for  $x = 0.5$ . This should produce the following terminal output:

```

0.583469689      0.594491422      1.10217333E-02  0.500000000
STOP Regular stop encountered

```

Repeat the calculation for  $x = -0.5$ ,  $0.8$ , and  $4.0$ . The respective terminal outputs are

```

0.922258496      0.874260426      4.79980707E-02 -0.500000000
0.460184008      0.452319026      7.86498189E-03  0.800000012
96.1266937       7.51371786E-04   96.1259460      4.00000000

```

6. Email a copy of your source code to `ewhart317@gmail.com`. Put `Last First WS 2` in the subject line, where Last and First is your Last and First name.