**Computational Physics Homework Assignment #2**

*March 25, 2019; Due April 15, 2019*

**Reading Assignment**

1. Read lecture notes and references; Study sample programs and prepare your own programs with any languages you prefer.
2. **Complete** one Lab Assignments before you lave the laboratory.

**Laboratory Assignments (Total Points: 120), on April 01, 2019**

1. (10 points) Consider the function at . Calculate its first and second derivatives for , using the forward and central difference formulae. Plot the log error versus . Compare your results with that of Richardson extrapolation.



1. (15 points) Use the two-point, three-point, and five-point formulae to estimate the first five derivatives of at .



As a check,



You are recommended to change the value of h in the fashion of , n = 1, 2, …



(Hint: please use forward two-point formulae to estimate first derivative, central three-point for first and second derivatives, central five-point for first four derivatives, central seven-point for fifth derivative. You can find coefficients at <https://en.wikipedia.org/wiki/Finite_difference_coefficient>)

1. (10 points) Use library functions and subroutines, to prove the following equalities *numerically*:

（1）



（2）



（3）



（4）



（5）



With

1. (20 points) Study the Hilbert matrix again.



Diagonalizing *Hn* and calculate the ratio of the largest eigenvalue to the smallest eigenvalue, log(*max*|**|/*min*|**|), and plot it as a function of *n*. Discuss your results.

Do the problem for both single and double precisions. Indicate which diagonalization routine you are using.

5. **Coupled Oscillators** (35 Points: 10, 10, 15)

Use program similar to *Oscillators* to solve the dynamics equation of motion for N=10 oscillators with the initial conditions . Compare numerical results of with the analytic one.



(a) What is the maximum deviation of ?



(b) How well is the total energy conserved as function of ?



(c) How well is the total energy conserved as function of if one uses Runge-Kutta 4th order algorithm?



1. (20 points) Table 3.1 lists a few values of Bessel functions. Estimate *J*1(4.5) by Lagrange polynomial interpolation for n = 1, 2, 3, and 5. Compare with exact value of *J*1(4.5) from math library. Recalculate *J*1(4.5) by Hermite interpolation for n 1, 3, and 5. The derivative of *J*1(x) is (*J*0(x) – *J*2(x))/2.

